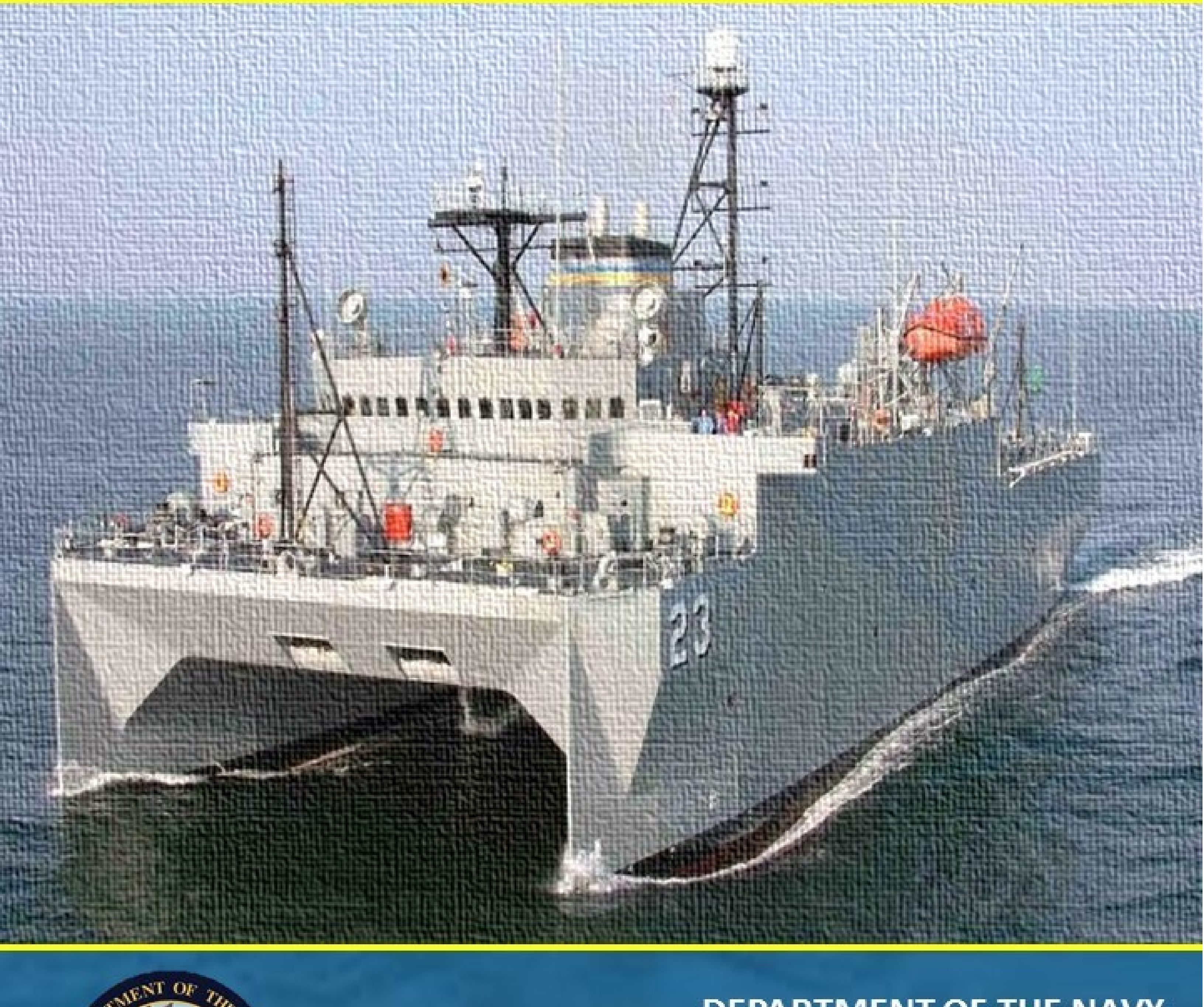
APPLICATION FOR RULEMAKING AND LETTER OF AUTHORIZATION UNDER THE MARINE MAMMAL PROTECTION ACT FOR ACTIVITIES ASSOCIATED WITH USE OF SURVEILLANCE TOWED ARRAY SENSOR SYSTEM LOW FREQUENCY ACTIVE (SURTASS LFA) SONAR



DEPARTMENT OF THE NAVY
CHIEF OF NAVAL OPERATIONS

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ACRONYMS AND ABBREVIATIONS

%	percent
>	greater than
<	less than
±	plus or minus
µ	micro (10^{-6})
AEP	auditory evoked potential
AIM	Acoustic Integration Model
APPS	Act to Prevent Pollution from Ships
ASW	antisubmarine warfare
BRS	behavioral response study
C	Celsius
CITES	Convention on International Trade in Endangered Species
CLFA	compact low frequency active
CW	continuous wave
CWA	Clean Water Act
dB	decibel(s)
dB re 1 µPa @ 1 m	decibels relative to one microPascal measured at one meter from center of acoustic source
dB re 1 µPa^2-sec	decibels relative to one microPascal squared second
DoN	Department of the Navy
DPS	distinct population segment
EO	Executive Order
ESA	Endangered Species Act
F	Fahrenheit
FM	frequency modulated
FOEIS/EIS	Final Overseas Environmental Impact Statement/Environmental Impact Statement
FSEIS/SOEIS	Final Supplemental Environmental Impact Statement/ Supplemental Overseas Environmental Impact Statement
ft	feet
HF	high frequency
HF/M3	high frequency marine mammal monitoring
HLA	horizontal line array
hr	hour(s)

Hz	hertz
IUCN	International Union of Conservation of Nature
IWC	International Whaling Commission
kg	kilogram(s)
km	kilometer(s)
kHz	kiloHertz
kph	kilometers per hour
kt	knot(s)
lb	pound(s)
LF	low frequency
LFA	Low Frequency Active
LFS	low frequency sound
LMR	Living Marine Resources
LOA	Letter of Authorization
m	meter(s)
M3	marine mammal monitoring
MF	mid-frequency
MILCREW	military crew
min	minute(s)
MMC	Marine Mammal Commission
MMPA	Marine Mammal Protection Act
MPA	Marine Protected Area
NDAA	National Defense Authorization Act
NDE	National Defense Exemption
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
nmi	nautical mile(s)
NMPAC	National Marine Protected Areas Center
NMS	national marine sanctuary
NRC	National Research Council
OBIA(s)	offshore biologically important area(s)
OEIS/EIS	Overseas Environmental Impact Statement and Environmental Impact Statement
OIC	Officer-in-charge
OPAREA	operating area

OW	otariid underwater
Pa	Pascal
PTS	permanent threshold shift
PW	phocid underwater
RL	received level
rms	root mean square
RV	research vessel
SAR	stock assessment report
sec	second(s)
SEIS/SOEIS	Supplemental Environmental Impact Statement/Supplemental Overseas Environmental Impact Statement
SEL	sound exposure level
SL	source level
SOCAL	Southern California
Sonar	SOund Navigation And Ranging
SoNG	Swatch-of-No-Ground
SPE	single ping equivalent
SPL	sound pressure level
SRP	Scientific Research Program
SURTASS	Surveillance Towed Array Sensor System
T-AGOS	Tactical-Auxiliary General Ocean Surveillance
TL	twin line
TTS	temporary threshold shift
U.S.	United States
U.S.C.	United States Code
USNS	United States Naval Ship
VLA	vertical line array
WDPA	World Database on Protected Areas

1 DESCRIPTION OF THE PROPOSED ACTIVITY

Requirement 1: A detailed description of the specific activity or class of activities that can be expected to result in the incidental taking of marine mammals.

1.1 Introduction

Pursuant to Section 101 (a)(5)(A) of the Marine Mammal Protection Act of 1972, as amended (MMPA; 16 United States Code [U.S.C.] 1371), the Department of the Navy (DoN; hereafter, the Navy) is applying for rulemaking and a Letter of Authorization (LOA) to continue utilizing Surveillance Towed Array Sensor System (SURTASS) Low Frequency Active (LFA) sonar systems onboard 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. The MMPA directs the Secretary of Commerce (Secretary) to allow, upon request, the incidental, but not intentional taking of marine mammals by United States (U.S.) citizens who engage in a specified activity (other than commercial fishing). The incidental take issuance occurs when the Secretary, after notice has been published in the *Federal Register* and opportunity for comment has been provided, finds that such takes would have a negligible impact on the species and stocks of marine mammals and would not have an unmitigable adverse impact on their availability for subsistence uses. Marine mammals have the potential to be incidentally harassed due to the underwater sound generated by the use of SURTASS LFA sonar. As a result, the Navy is requesting rulemaking and a LOA under the MMPA for taking of marine mammals by Level B harassment incidental to the use of SURTASS LFA sonar systems for training and testing activities within the western and central North Pacific and eastern Indian oceans.

This application for rulemaking and LOA is the fifth such application the Navy has submitted to the National Marine Fisheries Service (NMFS) for the use of SURTASS LFA sonar. In 2002, NMFS issued regulations and the initial LOA under the MMPA Final Rule (50 CFR §216 Subpart Q) (NOAA, 2002) for the operation of SURTASS LFA sonar on the research vessel (RV) *Cory Chouest*. The Navy requested and was issued annual LOA renewals in accordance with 50 CFR §216.189 for the remaining four years of the 2002 Final Rule for the RV *Cory Chouest* and U.S. Naval Ship (USNS) IMPECCABLE. In 2006, the Navy submitted its application for the second five-year Rule under the MMPA (DoN, 2006) for the taking of marine mammals incidental to the deployment of up to four SURTASS LFA sonar systems for military readiness activities from 16 August 2007 to 15 August 2012. NMFS published the second MMPA Final Rule in August 2007 (NOAA, 2007) for the employment of SURTASS LFA sonar, and subsequently issued annual LOAs for sonar use on the RV *Cory Chouest*, USNS VICTORIOUS, USNS ABLE, USNS EFFECTIVE and USNS IMPECCABLE. In 2011, the Navy submitted its application for the third five-year Rule under the MMPA (DoN, 2011) for the taking of marine mammals incidental to the deployment of up to four SURTASS LFA sonar systems from 15 August 2012 to 15 August 2017. NMFS published the third MMPA Final Rule in August 2012 (NOAA, 2012a) for the employment of SURTASS LFA sonar, and subsequently issued annual LOAs for sonar use on the USNS VICTORIOUS, USNS ABLE, USNS EFFECTIVE and USNS IMPECCABLE.

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 Final Rule for SURTASS LFA sonar. Both the Navy and NMFS carefully and fully considered the Ninth

Circuit's decision and have addressed it herein, as appropriate. The court ultimately dismissed the case later in 2017 as a result of a settlement agreement.

In 2016, the Navy submitted its application for the fourth five-year Rule under the MMPA (DoN, 2016) for the taking of marine mammals incidental to the deployment of up to four SURTASS LFA sonar systems from 15 August 2017 to 14 August 2022. On August 10, 2017, in consultation with the Secretary of Commerce and pursuant to Title 16, Section 1371(f) U.S.C., the Secretary of Defense determined that it was necessary for national defense to exempt all military readiness activities that use 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 LOA 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.

This application document has been prepared in accordance with applicable regulations and the MMPA, as amended by the National Defense Authorization Act (NDAA) for Fiscal Year 2004 (Public Law 108-136). The NDAA modified the MMPA by removing the ''small numbers'' and ''specified geographical region'' limitations and amended the definition of ''harassment'' as it applies to a ''military readiness activity."

The basis of this fifth application for rulemaking and LOA are: (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 scoped this application to reflect those areas of the world's oceans (the western and central North Pacific and eastern Indian oceans) where the Navy anticipates conducting SURTASS LFA sonar training and testing activities[1] (see Section 2.2). The Navy has provided greater detail on the types of SURTASS LFA sonar training and testing activities (see Section 2.1). The geographic scope would allow the Navy to more accurately assess and describe those impacts associated with SURTASSS LFA sonar training and testing activities in ocean areas where the Navy expects to conduct these activities.

1.2 Proposed Activity

The Navy proposes to continue utilizing SURTASS LFA sonar systems onboard USNS 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 Navy currently has four 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 fleet. The Navy proposes to use SURTASS LFA sonar systems onboard these vessels within the study area, which includes the western and central North Pacific and eastern Indian oceans.

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 the proposed activity, the

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[1] Throughout this document, the terms "training and testing activities" or "SURTASS LFA sonar activities" will be used to describe the proposed action of training and testing conducted under the authority of the Secretary of the Navy.

Navy would transmit 496 LFA sonar transmission hours per year pooled across all SURTASS LFA sonar equipped vessels in the first four years of the authorization, with an increase in usage to 592 LFA sonar transmission hours in authorization year five and continuing into the foreseeable future, regardless of the number of vessels.

The Navy proposes to implement procedural and geographic mitigation measures in association with the use of SURTASS LFA sonar for training and testing activities. Specifically, the Navy would not conduct SURTASS LFA sonar training and testing activities within the territorial seas of foreign nations and would ensure that LFA sonar received levels (RLs) are below 180 decibels relative to one microPascal (root mean squared) (dB re 1 µPa [rms]) within 12 nautical miles (nmi) (22 kilometers [km]) of any emergent land and at the boundary of any designated offshore biologically important areas (OBIAs) during their effective periods of biological activity. There are 29 designated OBIAs as described in the NDE, of which four are found in the proposed study area for SURTASS LFA sonar. 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 in the 180-dB mitigation zone for SURTASS LFA sonar and then suspending or delaying LFA sonar transmissions.

For this application, the Navy has determined that the only aspect of the proposed action with the potential to incidentally harass marine mammals is the transmission of acoustic signals during the use of SURTASS LFA sonar. Through the history of the SURTASS LFA sonar program, no vessel strikes of marine mammals, physical injury to any marine mammals, or marine mammal strandings have ever been observed, reported, or associated with the employment of SURTASS LFA sonar. Therefore, the remainder of this application focuses on the details associated with the Navy's employment of SURTASS LFA sonar for training and testing activities and its potential non-injurious impacts on marine mammal species and stocks.

1.3 Background

In 2004, the NDAA included amendments to the MMPA that apply where a "military readiness activity" is concerned. The term "military readiness activity" is defined in Public Law 107-314 (16 U.S.C. §703 note) to include 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. The NMFS and Navy have established that the Navy's training and testing activities for SURTASS LFA sonar constitute military readiness activities as defined by public law and constitute "adequate and realistic testing of military equipment, vehicles, weapons and sensors for proper operation and suitability for combat use" (NOAA, 2002).

During use of the SURTASS LFA sonar system, acoustic signals are introduced into the ocean that could potentially affect the marine environment. As a result, the Navy conducted analyses relevant to the potential environmental impacts of using the SURTASS LFA sonar system. The Navy has scoped the geographic extent in this application 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 in the foreseeable future. The Navy has provided greater detail on the types of SURTASS LFA sonar training and testing activities in Chapter 2. The revised geographic scope would allow the Navy to more accurately assess and describe those impacts associated with SURTASSS LFA sonar training and testing activities in areas where the Navy expects to conduct these activities. Concurrent with the development of this MMPA application, the Navy is developing a Draft

Supplemental EIS/Supplemental OEIS (DSEIS/SOEIS) (DoN, 2018a). The Navy is the lead agency and NMFS is the cooperating agency for the preparation of the DSEIS/SOEIS, which has been prepared in accordance with the requirements of the National Environmental Policy Act of 1969 (NEPA; 42 U.S.C. 4321 et seq.) and Executive Order (EO) 12114, Environmental Effects Abroad for Major Federal Actions.

1.4 Purpose and Need for SURTASS LFA Sonar

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. To meet the need for improved capability to detect quieter and harder-to-find foreign submarines at long range, before these vessels can get within their effective weapons range to launch missiles or torpedoes against U.S. ships or land targets, the Navy developed and uses SURTASS LFA sonar. SURTASS LFA sonar can be used day and night in a variety of weather conditions. The active acoustic component in the SURTASS LFA sonar system is an important augmentation to passive and tactical systems, as its long-range detection capabilities can effectively counter the threat to the U.S. Navy and national security posed by quiet submarines.

The purpose of the Navy's Proposed Activity 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 Activity is to maintain a system capable of detecting at long ranges the increasingly technologically advanced foreign submarine presence that threatens our national security.

1.5 SURTASS LFA Sonar Technology

SURTASS LFA sonar systems are long-range sensors that transmit in the low frequency (LF) band (i.e., below 1,000 Hertz [Hz]) and include both active and passive acoustic components (Figure 1-1). 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 off-the-shelf "fish finders" to military ASW systems 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

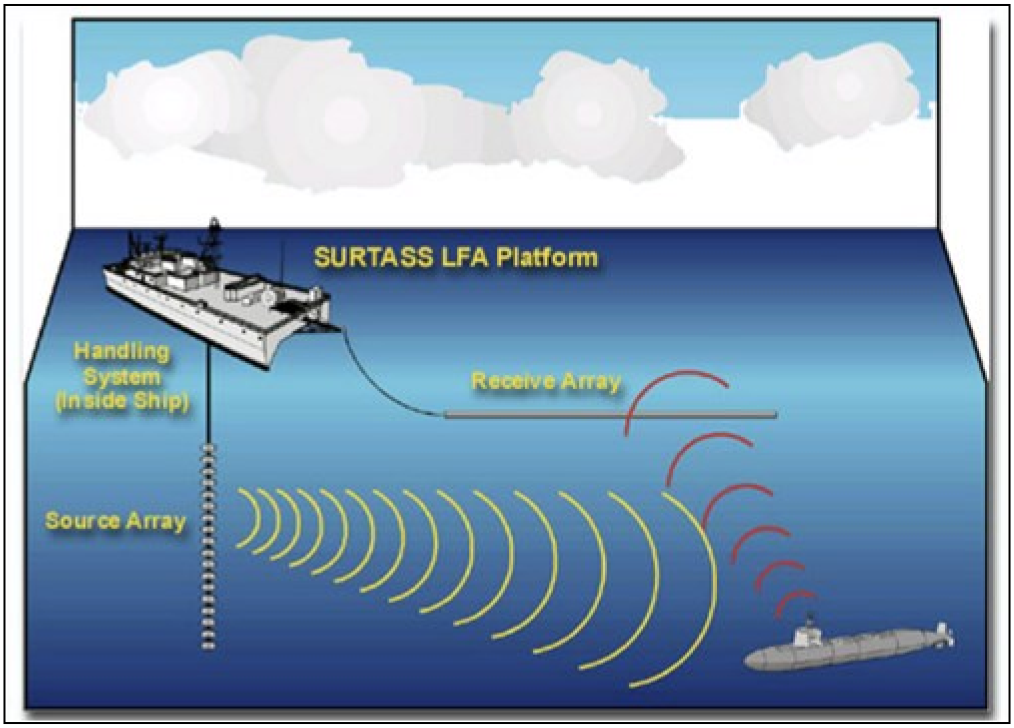

Figure 1-1. SURTASS LFA Sonar Systems Showing the Active (Source Array) and Passive (Receive Array) Components.

(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.

LFA sonar systems were initially installed on two SURTASS ocean surveillance ships, RV *Cory Chouest*, which was retired in 2008, and USNS IMPECCABLE (T-AGOS 23). As future undersea warfare requirements continue to transition to littoral ocean regions, a compact active system deployable on SURTASS ships was needed. This sonar system upgrade is known as Compact LFA, or CLFA. CLFA sonar consists of smaller, lighter-weight source elements than the LFA sonar system and is compact enough to be installed on the VICTORIOUS Class ships (such as T-AGOS 19, 20, and 21). CLFA improvements include:

- Transmission 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
- Lighter-weight design.

The operational characteristics of the CLFA sonar system are comparable to the LFA sonar system as presented in Subchapter 2.1 of the FOEIS/EIS (DoN, 2001) and FSEIS/SOEISs (DoN, 2007, 2012, 2017a). Therefore, the potential impacts from CLFA sonar are expected to be similar to, and not greater than, the impacts from the LFA sonar system. For this reason, the term LFA sonar is used to refer to both the LFA and/or the CLFA sonar systems, unless otherwise specified.

References to Underwater Sound Levels

- References to underwater sound pressure level (SPL) in this application are values given in decibels (dBs), and are assumed to be standardized at 1 microPascal at 1 m (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 (ANSI, 2006; Urick, 1983).
- In this application, 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 (ANSI, 2006; Southall et al., 2007; Urick, 1983).
- 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 mission 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 of the 2019 Draft SEIS/SOEIS for 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: FOEIS/FEIS (DoN, 2001), FSEIS (DoN, 2007), FSEIS/SOEIS (DoN, 2012), FSEIS/SOEIS (DoN, 2015), and FSEIS/SOEIS (DoN, 2017).

1.5.1 Active Acoustic System

The active component of the SURTASS LFA sonar system, LFA sonar, is an adjunct to the SURTASS passive capability and is used when active sound signals are needed to detect and track underwater targets. The characteristics and operating features of the active component of LFA sonar are:

- The sonar source is a vertical line array (VLA) of up to 18 source projectors suspended beneath the vessel. LFA's transmitted sonar beam is omnidirectional (360 degrees) in the horizontal, with a narrow vertical beamwidth that can be steered above or below the horizontal.
- The source frequency is between 100 and 500 Hz.
- The source level (SL) of an individual source projector of the SURTASS LFA sonar array is approximately 215 decibels relative to one microPascal measured at 1 m (dB re 1 µPa @ 1 m) sound pressure level (SPL) or less. As measured by SPL, the sound field of the array can never be higher than the SL of an individual source projector.
- The typical LFA sonar signal is not a constant tone, but a transmission of waveforms that vary in frequency and duration. A complete sequence of sound transmissions is referred to as a wavetrain (also known as a "ping"). These wavetrains last between 6 and 100 seconds (sec) with an average length of 60 sec. 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 is no longer than 10 sec.
- The maximum duty cycle (ratio of sound "on" time to total time) is 20 percent. The typical duty cycle, based on historical LFA sonar use (2003 to 2018), is 7.5 to 10 percent.

- The time between wavetrain transmissions is typically from 6 to 15 minutes (min).

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.

1.5.2 Passive Acoustic System

SURTASS is the passive, or listening, component of the system that detects returning echoes 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 processing system of the sonar. SURTASS consists of a twin-line (TL-29A) horizontal line array (HLA), which is a “Y” shaped array with two apertures that is approximately 1,000 feet (ft) (305 meters [m]) long. The TL-29A can be towed in shallow, littoral environments; provides significant directional noise rejection; and resolves bearing ambiguities without having to change the vessel’s course.

To tow the HLA, a SURTASS LFA sonar vessel typically maintains a speed of at least 3 knots (kt) (5.6 kilometers per hour [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 DURATION AND LOCATION OF SURTASS LFA SONAR USE

Requirement 2: Date(s) and duration of such activity and the specific geographic region where it will occur.

2.1 Duration

The annual LFA sonar transmission hours would be 496 hours total per year pooled across all SURTASS LFA sonar equipped vessels in the first four years of the authorization, with the number of transmit hours increasing to 592 hours across all vessels during year 5 and continuing into the foreseeable future, regardless of the number of vessels. The SURTASS LFA sonar vessels typically operate independently but may operate in conjunction with other naval air, surface, or submarine assets. The vessels generally travel in straight lines or racetrack patterns depending on the activity scenario.

In year 5 and beyond of this authorization, the Navy is planning to add new vessels to its ocean surveillance fleet. As new vessels are developed, the onboard LFA and HF/M3 sonar systems 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 would be ready for at-sea testing beginning in the fifth year of the time period covered by this application. Thus, the Navy's activity analysis included consideration of the sonar hours associated with future testing of new or updated LFA sonar system components and new ocean surveillance vessels. This consideration resulted in two scenarios of annual sonar transmit hours: Years 1 to 4 would entail 496 hours total per year across all SURTASS LFA sonar vessels, while year 5 and beyond would include an increase in LFA sonar transmit hours to 592 hours across all vessels to accommodate future testing of new ocean surveillance vessels and new or updated sonar system components.

The SURTASS LFA sonar transmission hours represent a distribution across six activities that include:

- Contractor crew proficiency training (80 hours per year)
- Military crew (MILCREW) proficiency training (96 hours per year)
- Participation in or support of Navy 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; would occur in year 5 and beyond)

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.

2.2 Potential SURTASS LFA Sonar Areas

The geographic scope of the previous MMPA 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 application is the western and central North Pacific and eastern Indian oceans, outside of the territorial seas (12 nmi [22 km]) of foreign nations (Figure 2-1).

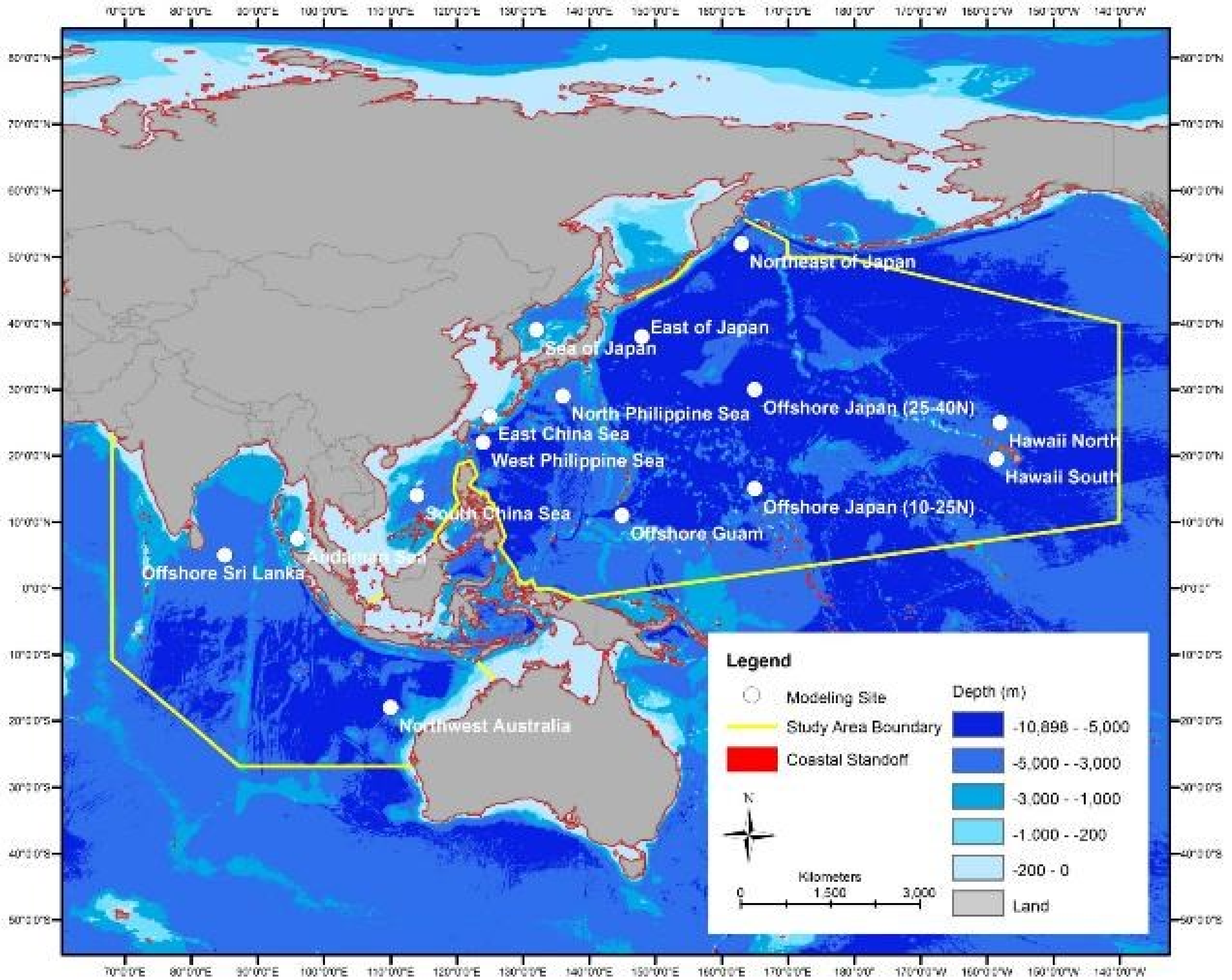

Figure 2-1. Study Area in the Western and Central North Pacific and Eastern Indian Oceans Including Nominal Modeling Sites.

Fifteen representative model areas, with nominal modeling sites in each region, provide geographic context. The Navy has 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.

Within this geographic scope, NMFS and the Navy developed mitigation measures to reduce the potential for adverse impacts, which include two geographic restrictions, the coastal standoff range and OBIAs. As such, during SURTASS LFA sonar training and testing activities, RLs would be below 180 dB re 1 µPa rms SPL within 12 nmi (22 km) of any emergent land and within the boundary of a designated OBIA during its respective effective period when significant biological activity occurs.

2.2.1 Geographic Restrictions—Coastal Standoff Range

Based on the analyses presented in NEPA documents for SURTASS LFA sonar (DoN, 2001, 2007, 2012, 2015, and 2017a), geographic restrictions to the use of SURTASS LFA sonar have been developed to provide the lowest risk to marine mammals. Since the majority of biologically important areas for protected marine mammal species and stocks are in coastal waters, the Navy established the mitigation measure of the coastal standoff range, in which waters within 12 nmi (22 km) of any emergent land would not be ensonified with SURTASS LFA sonar at levels at or above 180 dB re 1 µPa (rms). In addition, SURTASS LFA sonar training and testing activities would not occur within the territorial seas (12 nmi [22 km]) of foreign nations.

2.2.2 Geographic Restrictions—Offshore Biologically Important Areas (OBIAs) for Marine Mammals

Given the unique transmission characteristics of SURTASS LFA sonar, Navy and NMFS developed the concept of marine mammal OBIAs for SURTASS LFA sonar as part of the Navy's first NEPA documentation for SURTASS LFA sonar (DoN, 2001). In recognition that certain areas of biological importance lie outside the coastal standoff range, the Navy and NMFS developed the concept of OBIAs. OBIAs are part of a comprehensive suite of mitigation measures used in previous authorizations to minimize adverse impacts to marine mammal populations. OBIAs for SURTASS LFA sonar are not intended to apply to any other Navy activities or sonar operations and were established solely as a mitigation measure to reduce impacts associated with the employment of SURTASS LFA sonar (NOAA, 2007, 2012a).

Associated with each OBIA is an effective period during which the marine mammals for which the OBIA was designated carry out biologically significant activities. During that time period, SURTASS LFA sonar cannot be transmitted at RLs of greater than 180 dB re 1 µPa (rms) within the boundary of an OBIA. Twenty-nine OBIAs have been established for SURTASS LFA sonar globally; four of these OBIAs lie within the current study area for SURTASS LFA sonar.

2.2.2.1 OBIA Selection Criteria

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 and the measures against which the available data on marine areas are evaluated. This application carries forward those criteria.

2.2.2.1.1 Geographic Criteria for OBIA Eligibility

The Navy has defined the study area in which SURTASS LFA sonar would be used. For a marine area to be eligible for consideration as an OBIA for marine mammals, the area must be located where SURTASS LFA sonar would be used. As such, it cannot be located in:

- Coastal standoff range—the area within 12 nmi (22 km) of the coastline of any emergent land including islands or island systems.
- Polar regions—including the Arctic (such as the Bering Sea) and Antarctic (south of 60° S latitude).

2.2.2.1.2 Low-Frequency Hearing Sensitivity Criterion

Since SURTASS LFA sonar transmissions are well below the range of best hearing sensitivity for odontocetes and most pinnipeds, based on 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. Although OBIAs have been designated for non-LF hearing specialists, such as elephant seals and sperm whales, these scenarios were unique cases that involved deep-diving species engaged in biologically significant behaviors in pelagic concentrations, with some hearing data that indicated improved LF sensitivity for these species relative to other MF hearing specialists. The principal focus of the OBIA mitigation measure is on LF hearing sensitive species.

2.2.2.1.3 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:

- *High Densities*: A region of high density for one or more species of marine mammals. In addition to survey data, predictive habitat or density modeling may be used to identify areas of high density. The exact definition of “high density” may differ across species and should generally be treated and justified on a stock-by-stock or species-by-species basis, although combining species or stocks may be appropriate in some situations, if well justified. For locations/regions and species for which adequate density information is available (e.g., most waters off the U.S.), high density areas should be defined as those areas where density measurably, within a definable and justifiable area, meaningfully exceeds the average density of the species or stock in that location/region regularly or regularly within a designated time period of the year. For locations/regions and species and stocks for which density information is limited or not available, high density areas should be defined (if appropriate) using all other available data and information.
- *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 at least one biologically important activity is concentrated in the area. “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 Stock:* Areas designated as critical habitat under the Endangered Species Act (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.

2.2.2.1.4 Navy Practicability Criterion

Once an area has been assessed to meet the OBIA criteria, it is considered a candidate OBIA for SURTASS LFA sonar. The Navy then conducts a practicability review of the candidate OBIAs to assess personnel safety, practicality of implementation, and impacts on the effectiveness on military readiness activities. If no issues are found during the Navy's practicability review, then an area meets all criteria for designation as a SURTASS LFA sonar OBIA for marine mammals. If there are practicability concerns, Navy and NMFS engage in further discussions to determine if modifications to the OBIA would address those concerns.

2.2.2.2 Existing Marine Mammal OBIAs for SURTASS LFA Sonar

Under the NDE, 29 areas were observed as marine mammal OBIAs for SURTASS LFA sonar (Table 2-1; Figure 2-2; DoD, 2017). Some of these areas, such as the Antarctic Convergence Zone, had been previously designated as OBIAs by the Navy and NMFS for SURTASS LFA sonar. The season or period in which the biological activity occurs annually is specified for each designated OBIA. Of these 29 OBIAs, four occur in the proposed study area (Figure 2-3), 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).

2.2.2.3 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. The Navy and NMFS monitor scientific literature, data, and information that may support the potential marine areas or provide additional candidates for consideration as OBIAs for SURTASS LFA sonar. As a continuation of the Navy and NMFS' ongoing effort to assess areas as potential OBIAs for SURTASS LFA sonar, the Navy and NMFS are conducting a comprehensive assessment of potential marine areas as part of the analysis and development of geographic mitigation.

2.2.3 Representative Model Areas

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 2-2). Acoustic impact 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

Table 2-1. Existing 29 Offshore Biologically Important Areas (OBIAs) for SURTASS LFA Sonar, the Relevant 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 National Marine Sanctuary (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 September, annually
6	Navidad Bank	Caribbean Sea/Northwest Atlantic Ocean	Humpback whale	December through April, annually
7	Coastal Western Africa (Cameron 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 2-1. Existing 29 Offshore Biologically Important Areas (OBIAs) for SURTASS LFA Sonar, the Relevant 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, 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	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	Blue whale	February to April, annually

Table 2-1. Existing 29 Offshore Biologically Important Areas (OBIAs) for SURTASS LFA Sonar, the Relevant 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*
26	Offshore Sri Lanka	North-Central Indian Ocean	Blue whale	December through April, annually
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	Sperm whale	Year-round

- 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. Winter (December, January, and February) in the southern hemisphere is austral summer, when for instance, most baleen whales would be expected to be foraging in Antarctic waters.

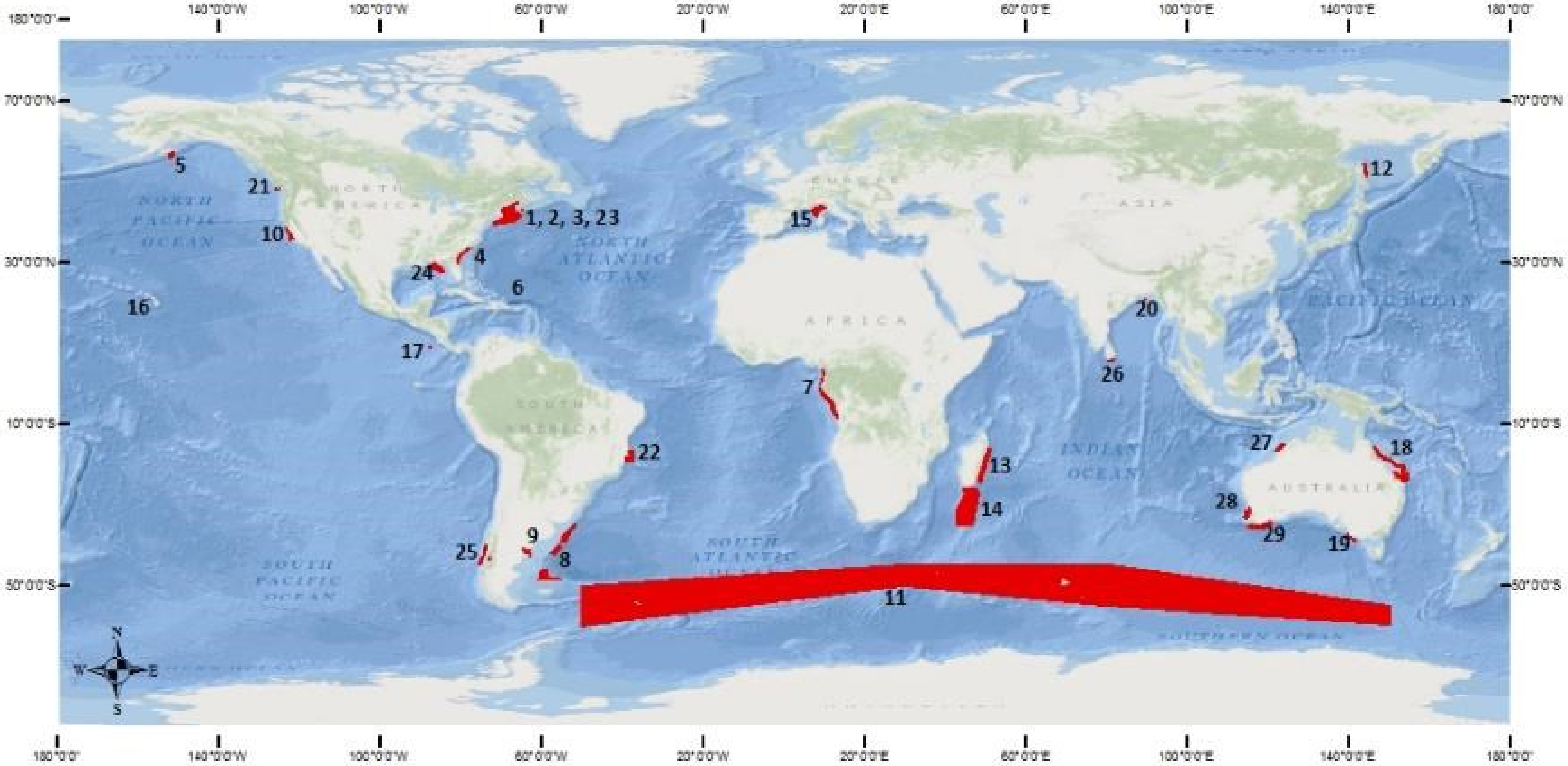

Figure 2-2. Locations of the 29 Existing Marine Mammal Offshore Biologically Important Areas (OBIAs) for SURTASS LFA Sonar (the Names of OBIAs by Number Follows).

FIGURE 2-2: 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. North Pacific Right Whale Critical Habitat
6. Navidad Bank
7. Coastal Waters of Gabon, Congo and Equatorial Guinea
8. Patagonian Shelf Break
9. Southern Right Whale Seasonal Habitat
10. Central California National Marine Sanctuaries
11. Antarctic Convergence Zone
12. Piltun and Chayvo Offshore Feeding Grounds
13. Coastal Waters off Madagascar
14. 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 Between 16°S and 21°S
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

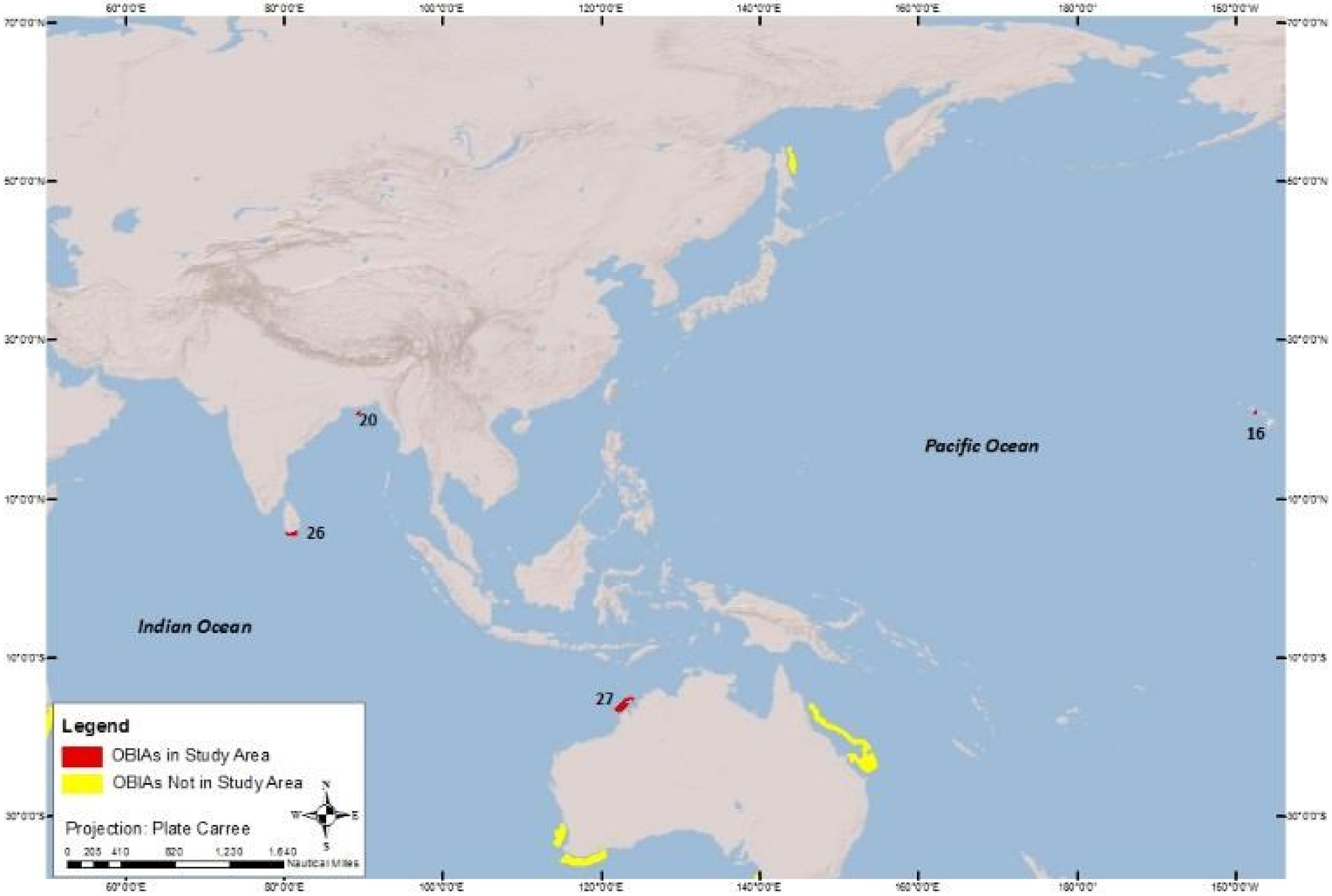

Figure 2-3. Locations of the Four OBIAs (16, 20, 26, and 27) in the SURTASS LFA Sonar Study Area.

Table 2-2. Locations of the 15 Representative Model Areas for SURTASS LFA Sonar Training and Testing Activities with the Nominal Center of each Area.

Model Area	*Model Area Name*	*Location of Model Area Center*	*Notes*
1	East of Japan	38°N, 148°E	Adjacent to Navy Japan Complex OPAREA
2	North Philippine Sea	29°N, 136°E	Adjacent to Navy Japan/Okinawa Complex OPAREA
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	Navy Japan/Okinawa Complex OPAREA
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 Training and Testing Area; Hawaii Operating Area
11	Hawaii South	19.5°N, 158.5°W	Navy Hawaii-Southern California Training and Testing 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	

3 MARINE MAMMALS

Requirement 3: The species and numbers of marine mammals likely to be found within an activity area.

To establish the marine mammal species or stocks potentially affected by SURTASS LFA sonar activities, two essential screening criteria were applied: the species or stocks had to occur at least seasonally in a representative model area and had to possess sensory organs or tissues that allow the marine mammals to perceive the LF sounds produced by the sonar. Only those species of marine mammals meeting these criteria are considered further in this application.

In cases where direct evidence of acoustic sensitivity to LF or any other frequency range is lacking for a species, reasonable indirect evidence was used to support the evaluation (e.g., there is no direct evidence that a species hears LF sound but good evidence exists that the species produces LF sound). In cases where important biological information was not available or was insufficient for one species but data were available for a related species, the comparable data were used. Additional attention was given to species with either special protected stock status or limited potential for reproductive replacement in the event of mortality.

3.1 Marine Mammal Species Occurrence

Forty-eight species or species groups (e.g., *Mesoplodon* spp.) representing 139 stocks of marine mammals capable of perceiving LF sounds potentially occur in the ocean areas in which SURTASS LFA sonar may be used (Society for Marine Mammalogy [SMM], 2017). Included are ten species of mysticete (baleen) whales, 33 species/species groups of odontocete (toothed) whales (31 individual species), and five species of pinnipeds (Table 3-1). Some of these species are only found seasonally in the SURTASS LFA study area while others occur year-round. Due to the restrictions imposed by no training and testing activities being conducted in the territorial seas of foreign nations as well as the geographic mitigation measures for the power level of LFA sonar in the coastal standoff range and OBIAs, coastally-occurring, inshore, and nearshore species, such as sirenians and river dolphins, are not included in the underwater acoustic risk assessment completed for SURTASS LFA sonar training and testing activities.

3.2 Marine Mammal Abundance and Density Estimates

For this application and the Draft SEIS/SOEIS (DoN, 2018a), risk to the possible 48 marine mammal species/species groups associated with the transmission of LF sound was derived for 15 potential SURTASS LFA sonar model areas (Table 2-2). Although the distribution of many marine mammal species is irregular and highly dependent upon geography, oceanography, and seasonality, population (density and abundance) estimates for each marine mammal species or stock occurring in an activity area are critical components of the analytical estimation methodology to assess risk to marine mammal populations from activities occurring in the marine environment.

The process for developing density and abundance estimates for every species possibly occurring in the potential model areas was a multi-step procedure that first utilized data with the highest degree of fidelity. Abundance estimates are typically more available than are density estimates, which require

Table 3-1. Marine Mammal Species Evaluated in this Application 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)*[2]		
	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)*		

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[2] 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 3-1. Marine Mammal Species Evaluated in this Application 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)*		
	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 (*Hyperodon 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)*[3]		
	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*)		

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[3] 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 3-1. Marine Mammal Species Evaluated in this Application 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*
Delphinidae (Continued)	Risso's dolphin (*Grampus griseus*)		
	Rough-toothed dolphin (*Steno bredanensis*)		
	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

more sophisticated sampling and analysis and are not always available for each species/stocks or distinct population segment (DPS) in all model areas. In the rare cases where no abundance estimates were available for the stock of a species, an abundance derived for another stock of the same species or for a similar species in the same oceanographic area might be used as a surrogate abundance. These population data were derived using the best available information and data (Table 3-2), including the most current NMFS final Stock Assessment Reports (SARs) for U.S. Alaska and North Pacific waters (Carretta et al., 2018; Muto et al., 2018), respectively, or the SAR that was relevant for a species' or stock's information.

To derive density estimates, direct estimates from line-transect surveys that occurred in or near each of the 15 model areas were utilized first (e.g., Bradford et al., 2017). However, density estimates require more sophisticated sampling and analysis and were not always available for each species/stock at all model areas. When density estimates were not available from a survey in the study area, density estimates from a region with similar oceanographic characteristics were extrapolated to the study area. For example, the eastern tropical Pacific has been extensively surveyed and provides a comprehensive understanding of marine mammals in temperate oceanic waters (Ferguson and Barlow, 2001, 2003). Densities for some model areas were also derived from the Navy's Marine Species Density Database (DoN, 2018b). Last, density estimates are usually not available for 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 0.0001 animals per square kilometer (animals/km^2) was used in the risk analysis for SURTASS LFA sonar to reflect the low probability of occurrence in a specific SURTASS LFA sonar model area. 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 or the species are difficult to distinguish at sea. This is often the case for beaked whales (e.g., *Mesoplodon* spp.), as well as the pygmy and dwarf sperm whales (*Kogia* spp.). Density estimates are available for these species groups rather than the individual species (Table 3-2).

Table 3-2. Marine Mammal Species, Stocks (DPSs), Abundance Estimates, and Density Estimates by Season as well as the Associated References for the 15 Representative SURTASS LFA Sonar Model Areas in the Central and Western North Pacific Ocean and Eastern Indian Ocean (References Shown at End of Table).

Marine Mammal Species	*Stock Name*[4]	*Abundance*	*Abundance References*	*Density (animals per km^2)*[5]				*Density reference(s)*
				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[6]	1,328	45			0.00036	0.00036	4, 7
North Pacific right whale	WNP	922	46	0.00001[7]	0.00001			
Sei whale	NP	7,000	1, 47	0.0006	0.0006	0.0006	0.0006	1, 8
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
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

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[4] 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; SH= Southern Hemisphere; YS=Yellow Sea; OE=Offshore; OW=Nearshore; JW=Sea of Japan (minke); JE=Pacific coast of Japan

[5] No density in a season means that the marine mammal is not expected to occur in that mission area during that season.

[6] 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.

[7] 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.

Table 3-2. Marine Mammal Species, Stocks (DPSs), Abundance Estimates, and Density Estimates by Season as well as the Associated References for the 15 Representative SURTASS LFA Sonar Model Areas in the Central and Western North Pacific Ocean and Eastern Indian Ocean (References Shown at End of Table).

Marine Mammal Species	***Stock Name[4]***	***Abundance***	***Abundance References***	***Density (animals per km^2)[5]***				***Density reference(s)***
				Winter	***Spring***	***Summer***	***Fall***	
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

Table 3-2. Marine Mammal Species, Stocks (DPSs), Abundance Estimates, and Density Estimates by Season as well as the Associated References for the 15 Representative SURTASS LFA Sonar Model Areas in the Central and Western North Pacific Ocean and Eastern Indian Ocean (References Shown at End of Table).

Marine Mammal Species	*Stock Name*[4]	*Abundance*	*Abundance References*	*Density (animals per km²)*[5]				*Density reference(s)*
				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	0.0031	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	11, 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

Table 3-2. Marine Mammal Species, Stocks (DPSs), Abundance Estimates, and Density Estimates by Season as well as the Associated References for the 15 Representative SURTASS LFA Sonar Model Areas in the Central and Western North Pacific Ocean and Eastern Indian Ocean (References Shown at End of Table).

Marine Mammal Species	*Stock Name*[4]	*Abundance*	*Abundance References*	*Density (animals per km^2)*[5]				*Density reference(s)*
				Winter	*Spring*	*Summer*	*Fall*	
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
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	0.00015	0.00015	0.00015	0.00015	39
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

Table 3-2. Marine Mammal Species, Stocks (DPSs), Abundance Estimates, and Density Estimates by Season as well as the Associated References for the 15 Representative SURTASS LFA Sonar Model Areas in the Central and Western North Pacific Ocean and Eastern Indian Ocean (References Shown at End of Table).

Marine Mammal Species	***Stock Name***[4]	***Abundance***	***Abundance References***	***Density (animals per km^2)***[5]				***Density reference(s)***
				Winter	***Spring***	***Summer***	***Fall***	
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
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	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

Table 3-2. Marine Mammal Species, Stocks (DPSs), Abundance Estimates, and Density Estimates by Season as well as the Associated References for the 15 Representative SURTASS LFA Sonar Model Areas in the Central and Western North Pacific Ocean and Eastern Indian Ocean (References Shown at End of Table).

Marine Mammal Species	*Stock Name*[4]	*Abundance*	*Abundance References*	*Density (animals per km^2)*[5]				*Density reference(s)*
				Winter	*Spring*	*Summer*	*Fall*	
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
Cuvier's beaked whale	WNP	90,725	2, 3	0.0031	0.0031	0.0031	0.0031	2, 3
Dall's porpoise	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

Table 3-2. Marine Mammal Species, Stocks (DPSs), Abundance Estimates, and Density Estimates by Season as well as the Associated References for the 15 Representative SURTASS LFA Sonar Model Areas in the Central and Western North Pacific Ocean and Eastern Indian Ocean (References Shown at End of Table).

Marine Mammal Species	*Stock Name*[4]	*Abundance*	*Abundance References*	*Density (animals per km^2)*[5]				*Density reference(s)*
				Winter	*Spring*	*Summer*	*Fall*	
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
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	

Table 3-2. Marine Mammal Species, Stocks (DPSs), Abundance Estimates, and Density Estimates by Season as well as the Associated References for the 15 Representative SURTASS LFA Sonar Model Areas in the Central and Western North Pacific Ocean and Eastern Indian Ocean (References Shown at End of Table).

Marine Mammal Species	*Stock Name*[4]	*Abundance*	*Abundance References*	*Density (animals per km^2)*[5]				*Density reference(s)*
				Winter	*Spring*	*Summer*	*Fall*	
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
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

Table 3-2. Marine Mammal Species, Stocks (DPSs), Abundance Estimates, and Density Estimates by Season as well as the Associated References for the 15 Representative SURTASS LFA Sonar Model Areas in the Central and Western North Pacific Ocean and Eastern Indian Ocean (References Shown at End of Table).

Marine Mammal Species	*Stock Name*[4]	*Abundance*	*Abundance References*	*Density (animals per km^2)*[5]				*Density reference(s)*
				Winter	*Spring*	*Summer*	*Fall*	
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
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

Table 3-2. Marine Mammal Species, Stocks (DPSs), Abundance Estimates, and Density Estimates by Season as well as the Associated References for the 15 Representative SURTASS LFA Sonar Model Areas in the Central and Western North Pacific Ocean and Eastern Indian Ocean (References Shown at End of Table).

Marine Mammal Species	*Stock Name*[4]	*Abundance*	*Abundance References*	*Density (animals per km^2)*[5]				*Density reference(s)*
				Winter	*Spring*	*Summer*	*Fall*	
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
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	0.0029			0.0029	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

Table 3-2. Marine Mammal Species, Stocks (DPSs), Abundance Estimates, and Density Estimates by Season as well as the Associated References for the 15 Representative SURTASS LFA Sonar Model Areas in the Central and Western North Pacific Ocean and Eastern Indian Ocean (References Shown at End of Table).

Marine Mammal Species	*Stock Name*[4]	*Abundance*	*Abundance References*	*Density (animals per km^2)*[5]				*Density reference(s)*
				Winter	*Spring*	*Summer*	*Fall*	
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
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

Table 3-2. Marine Mammal Species, Stocks (DPSs), Abundance Estimates, and Density Estimates by Season as well as the Associated References for the 15 Representative SURTASS LFA Sonar Model Areas in the Central and Western North Pacific Ocean and Eastern Indian Ocean (References Shown at End of Table).

Marine Mammal Species	***Stock Name[4]***	***Abundance***	***Abundance References***	***Density (animals per km^2)[5]***				***Density reference(s)***
				Winter	***Spring***	***Summer***	***Fall***	
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
Pygmy sperm whale	Hawaii	7,138	14, 71	0.0029	0.0029	0.0029	0.0029	14

Table 3-2. Marine Mammal Species, Stocks (DPSs), Abundance Estimates, and Density Estimates by Season as well as the Associated References for the 15 Representative SURTASS LFA Sonar Model Areas in the Central and Western North Pacific Ocean and Eastern Indian Ocean (References Shown at End of Table).

Marine Mammal Species	*Stock Name*[4]	*Abundance*	*Abundance References*	*Density (animals per km^2)*[5]				*Density reference(s)*
				Winter	*Spring*	*Summer*	*Fall*	
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	184	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

Table 3-2. Marine Mammal Species, Stocks (DPSs), Abundance Estimates, and Density Estimates by Season as well as the Associated References for the 15 Representative SURTASS LFA Sonar Model Areas in the Central and Western North Pacific Ocean and Eastern Indian Ocean (References Shown at End of Table).

Marine Mammal Species	*Stock Name⁴*	*Abundance*	*Abundance References*	*Density (animals per km²)⁵*				*Density reference(s)*
				Winter	*Spring*	*Summer*	*Fall*	
Common bottlenose dolphin (Continued)	Hawaii Island	743	24, 71	0.028	0.028	0.028	0.028	24
	Kauai/Niihau	128	24, 71	0.065	0.065	0.065	0.065	24
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

Table 3-2. Marine Mammal Species, Stocks (DPSs), Abundance Estimates, and Density Estimates by Season as well as the Associated References for the 15 Representative SURTASS LFA Sonar Model Areas in the Central and Western North Pacific Ocean and Eastern Indian Ocean (References Shown at End of Table).

Marine Mammal Species	*Stock Name*[4]	*Abundance*	*Abundance References*	*Density (animals per km^2)*[5]				*Density reference(s)*
				Winter	*Spring*	*Summer*	*Fall*	
Spinner dolphin (Continued)	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								
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

Table 3-2. Marine Mammal Species, Stocks (DPSs), Abundance Estimates, and Density Estimates by Season as well as the Associated References for the 15 Representative SURTASS LFA Sonar Model Areas in the Central and Western North Pacific Ocean and Eastern Indian Ocean (References Shown at End of Table).

Marine Mammal Species	*Stock Name*[4]	*Abundance*	*Abundance References*	*Density (animals per km^2)*[5]				*Density reference(s)*
				Winter	*Spring*	*Summer*	*Fall*	
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	31
Bryde's whale	NIND	9,176	77, 78	0.00038	0.00036	0.00037	0.00037	31
Common minke whale	IND	257,500	77		0.00001	0.00968	0.00001	31
Fin whale	IND	1,846	77	0.00001	0.00001		0.00001	31
Omura's whale	NIND	9,176	77	0.00038	0.00036	0.00037	0.00037	31
Blainville's beaked whale	IND	16,867	78	0.00094	0.00089	0.00094	0.00099	31
Common bottlenose dolphin	NIND	785,585	78	0.07578	0.07781	0.07261	0.07212	31
Cuvier's beaked whale	NIND	27,272	78	0.00466	0.00482	0.00480	0.00473	31
Deraniyagala beaked whale	IND	16,867	78	0.00094	0.00092	0.00097	0.00099	31
Dwarf sperm whale	IND	10,541	78	0.00005	0.00006	0.00006	0.00005	31
False killer whale	IND	144,188	78	0.00023	0.00023	0.00024	0.00023	31
Fraser's dolphin	IND	151,554	78	0.00176	0.00179	0.00180	0.00180	31
Ginkgo-toothed beaked whale	IND	16,867	78	0.00094	0.00092	0.00097	0.00099	31
Indo-Pacific bottlenose	IND	7,850	78	0.00076	0.00078	0.00073	0.00072	31
Killer whale	IND	12,593	78	0.00744	0.00178	0.00730	0.00734	31
Longman's beaked whale	IND	1,819,882	78	0.00444	0.00429	0.00459	0.00440	31
Melon-headed whale	IND	16,867	78	0.00884	0.00848	0.00878	0.00846	31
Pantropical spotted dolphin	IND	64,600	78	0.00868	0.00841	0.00829	0.00873	31
Pygmy killer whale	IND	736,575	78	0.00121	0.00113	0.00125	0.00131	31
Pygmy sperm whale	IND	22,029	78	0.00001	0.00001	0.00001	0.00001	31
Risso's dolphin	IND	10,541	78	0.09197	0.09215	0.09173	0.09366	31

Table 3-2. Marine Mammal Species, Stocks (DPSs), Abundance Estimates, and Density Estimates by Season as well as the Associated References for the 15 Representative SURTASS LFA Sonar Model Areas in the Central and Western North Pacific Ocean and Eastern Indian Ocean (References Shown at End of Table).

Marine Mammal Species	*Stock Name*[4]	*Abundance*	*Abundance References*	*Density (animals per km²)*[5] *Winter*	*Spring*	*Summer*	*Fall*	*Density reference(s)*
Rough-toothed dolphin	IND	452,125	78	0.00077	0.00078	0.00077	0.00074	31
Short-finned pilot whale	IND	156,690	78	0.03354	0.03364	0.03543	0.03504	31
Sperm whale	NIND	268,751	78, 79	0.00109	0.00099	0.00107	0.00105	31
Spinner dolphin	IND	24,446	78	0.00736	0.00711	0.00701	0.00726	31
Striped dolphin	IND	634,108	78	0.14413	0.14174	0.14123	0.14402	31
Model Area #14: Northwest of Australia[8]								
Antarctic minke whale	ANT	90,000	80		0.00001	0.00001	0.00001	31
Blue whale/Pygmy Blue Whale	SIND	1,657	81, 82		0.00003	0.00003	0.00003	31
Bryde's whale	SIND	13,854	83	0.00032	0.00032	0.00032	0.00032	31
Common minke whale	IND	257,500	77		0.01227	0.01929	0.01947	31
Fin whale	SIND	38,185	84, 85	0.00001	0.00099	0.00128	0.00121	31
Humpback whale	WAU stock and DPS	13,640	86		0.00007	0.00007	0.00007	31
Omura's whale	SIND	13,854	83	0.00032	0.00032	0.00032	0.00032	31
Sei whale	SIND	13,854	83	0.00001	0.00001	0.00001	0.00001	31
Blainville's beaked whale	IND	16,867	78	0.00083	0.00083	0.00082	0.00083	31
Common bottlenose dolphin	WAU	3,000	87	0.03630	0.03652	0.03459	0.03725	31
Cuvier's beaked whale	SH	76,500	88	0.00399	0.00406	0.00402	0.00405	31
Dwarf sperm whale	IND	10,541	78	0.00004	0.00004	0.00004	0.00004	31
False killer whale	IND	144,188	78	0.00020	0.00020	0.00019	0.00020	31
Fraser's dolphin	IND	151,554	78	0.00145	0.00148	0.00149	0.00147	31
Killer whale	IND	12,593	78	0.00585	0.00435	0.00588	0.00580	31
Longman's beaked whale	IND	16,867	78	0.00393	0.00393	0.00403	0.00412	31

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[8] 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.

Table 3-2. Marine Mammal Species, Stocks (DPSs), Abundance Estimates, and Density Estimates by Season as well as the Associated References for the 15 Representative SURTASS LFA Sonar Model Areas in the Central and Western North Pacific Ocean and Eastern Indian Ocean (References Shown at End of Table).

Marine Mammal Species	*Stock Name*[4]	*Abundance*	*Abundance References*	*Density (animals per km^2)*[5]				*Density reference(s)*
				Winter	*Spring*	*Summer*	*Fall*	
Melon-headed whale	IND	64,600	78	0.00717	0.00717	0.00635	0.00637	31
Pantropical spotted dolphin	IND	736,575	78	0.00727	0.00727	0.00715	0.00746	31
Pygmy killer whale	IND	22,029	78	0.00100	0.00104	0.00101	0.00097	31
Risso's dolphin	IND	452,125	78	0.07152	0.07214	0.06944	0.07173	31
Rough-toothed dolphin	IND	156,690	78	0.00059	0.00060	0.00059	0.00059	31
Short-finned pilot whale	IND	268,751	78	0.02698	0.02759	0.02689	0.02716	31
Southern bottlenose whale	IND	599,300	78	0.00083	0.00083	0.00082	0.00083	31
Spade-toothed beaked whale	IND	16,867	78	0.00083	0.00083	0.00082	0.00083	31
Sperm whale	SIND	24,446	78	0.00096	0.00087	0.00097	0.00092	31
Spinner dolphin	IND	634,108	78	0.00561	0.00549	0.00568	0.00563	31
Striped dolphin	IND	674,578	78	0.12018	0.12041	0.11680	0.11727	31
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

Table 3-2. Marine Mammal Species, Stocks (DPSs), Abundance Estimates, and Density Estimates by Season as well as the Associated References for the 15 Representative SURTASS LFA Sonar Model Areas in the Central and Western North Pacific Ocean and Eastern Indian Ocean (References Shown at End of Table).

Marine Mammal Species	*Stock Name[4]*	*Abundance*	*Abundance References*	*Density (animals per km^2)[5]*				*Density reference(s)*
				Winter	*Spring*	*Summer*	*Fall*	
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 3-2 CITED LITERATURE REFERENCES

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

4 STATUS AND DISTRIBUTION OF POTENTIALLY AFFECTED MARINE MAMMAL SPECIES AND STOCKS

Requirement 4: Description of the status, distribution, and seasonal distribution of the affected species or stocks of marine mammals likely to be affected by such activities.

The status, distribution, stocks, abundance, diving behavior, life history, and hearing/vocalization for each of the marine mammal species potentially found in the study area are the focus of this chapter. The status of marine mammal populations is impacted by their biological characteristics, natural phenomenon, and interaction with anthropogenic activity. Many cetacean and pinniped populations have been reduced due to the exploitation of commercial whaling and harvesting, incidental fisheries bycatch, harmful algal blooms, and habitat destruction over the last centuries. The reduction in some marine mammal populations has led to the risk of extinction. The ESA, along with the international organizations such as the International Union of Conservation of Nature (IUCN), designate a protected status when species are at risk of extinction, generally based on natural or manmade factors affecting the continued existence of species. In addition, under the MMPA, species or stocks that are not at the optimal sustainable population level may be listed as depleted.

The distribution of marine mammals is difficult to predict as these highly mobile animals are capable of traveling long distances. Many species of marine mammals move extensive distances between feeding grounds at high latitudes during warmer seasons and calving/breeding grounds in the lower latitudes during colder seasons. Some baleen whales, such as the humpback whale, make extensive annual migrations to low-latitude mating and calving grounds in the winter and to high-latitude feeding grounds in the spring and summer, traveling over 5,292 nmi (9,800 km) one way, which is the longest known migration of any mammal (Stevick et al., 2011). Despite this 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 often associated with features such as oceanographic fronts or regions of persistent upwelling because these areas of increased primary productivity attract marine mammal prey, such as squid and fishes.

4.1 Mysticetes

Mysticetes potentially affected by SURTASS LFA sonar include 10 species in three families (Table 3-1). Mysticetes are characterized by paired blowholes and the large baleen plates used to capture zooplankton and small fishes. Due to decades of whaling, many mysticete species and populations are imperiled throughout their worldwide ranges.

All mysticetes produce LF sounds, although no direct measurements of auditory (hearing) thresholds have been made for any mysticete species as most tests for auditory measurements are impractical in such large animals (Clark, 1990; Richardson et al., 1995; Edds-Walton, 1997; Tyack, 2000; Evans and Raga, 2001). A few species' vocalizations are known to be communication signals but the function of other mysticete LF sounds are not fully understood although likely are used for functions such as orientation, navigation, or detection of predators and prey. Several mysticete species, including the humpback, fin, and blue whales, sing or emit repetitious patterned signals or vocalizations (Frankel, 2009). Based on a study of the morphology of cetacean auditory mechanisms, Ketten (1994) hypothesized that mysticete hearing is in the low to infrasonic frequency range. It is generally believed that baleen whales have frequencies of best hearing where their calls have the greatest energy—below 5,000 Hz (Ketten, 2000).

4.1.1 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 estimate of 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 (Perrin et al. 2018; Reilly et al. 2008b). 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 that 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., 2014). 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., 2014). The bio-duck sound appears to be produced when whales are at the sea surface before foraging dives.

4.1.2 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 currently listed as endangered under the ESA; depleted under the MMPA;

protected under the Convention on International Trade in Endangered Species (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 move 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 seasonall 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, 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. (2008b) 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 and frequency modulated components with frequencies ranging from 20 to 750 Hz, and durations between 0.9 and 4.4 sec (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 1 to 2 seconds (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). It has been suggested that song characteristics could indicate population structure (McDonald et al., 2006). 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. A recent study recorded four calls during ~22 hours (Akamatsu et al., 2014).

4.1.3 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 Pacific (ETP), 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-taggeed Bryde's whales in the offshore waters of the western North Pacific Ocean did not remain in the northen, 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 Madiera Island was 9.4 min, with routine dives lasting 5 min, and mean dive durations of 0.4 to 6 min (Alves et al., 2010). Dive durations of Bryde's whales off Venezuela were from 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).

4.1.4 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 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 3-1) 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 averaing 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 meaured (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, 2009; 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).

4.1.5 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 3-1). Since these subspecies are not differentiated at sea or in available population data and information, hereafter all information about the fin whale is only 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, 2001; 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 nertic waters, but typically when deep water approaches near to land (Jefferson et al., 2015). Although fin whales have traditionally been thought of as 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 depths between 328 to 656 ft (100 and 200 m), with foraging dives lasting from 3 to 10 min (Aguilar, 2009; Witteveen et al., 2015). When traveling, fin whales have been recorded diving only to an average of 194 ft (59 m) (Croll et al., 2001). Swimming speeds average between 5 to 8 kt (9.2 and 14.8 kph) (Aguilar and García-Vernet, 2018). 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, and Atlantic fin whales also produce higher frequency downsweeps ranging from 100 to 30 Hz (Frankel, 2009). 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).

4.1.6 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, but 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 still remain (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 andmean 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 have dive times as long as 7 min, with a mean dive duration of 4 min. Swim speeds during migration average 2.4 to 4.9 kt (4.5 to 9 kph), and when pursued may reach 8.64 kt (16 kph) (Jones and Swartz, 2009). Gray whales migrating in Canadian waters swum at 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 received levels 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).

4.1.7 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; Minton et al., 2008; Reilly et al., 2008f). The worldwide ESA status of the humpback whale has been revised, with 14 worldwide DPSs identified (Figure 4-1). 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 3-1). 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 3-1). However, since these subspecies are not differentiated at sea or in available population data and information, all information about the humpback whale that follows is 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 4-1). 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, Phliippines, 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 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 4-2).

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., 2008a; Muto et al., 2018). In the eastern Indian Ocean, the 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

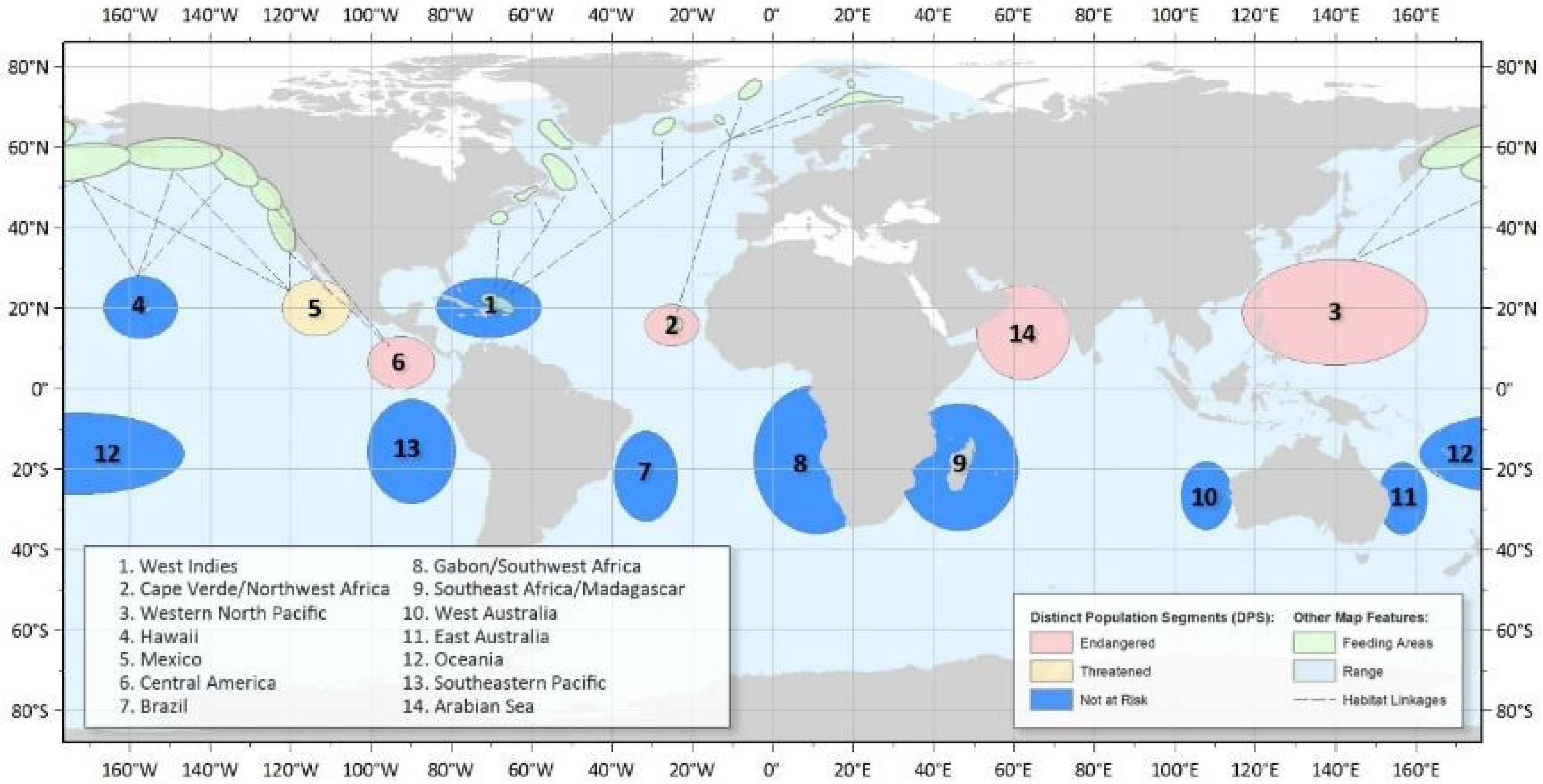

Figure 4-1. The Worldwide Distinct Population Segments (DPSs) of the Humpback Whale Listed Under the ESA. Four DPSs are Listed as Endangered (Arabian Sea, Cape Verde/Northwest Africa, Central America, and Western North Pacific), while One DPS (Mexico) is Listed as Threatened and all Other 10 DPSs not Listed Under the ESA. Image Courtesy of NMFS (2016c).

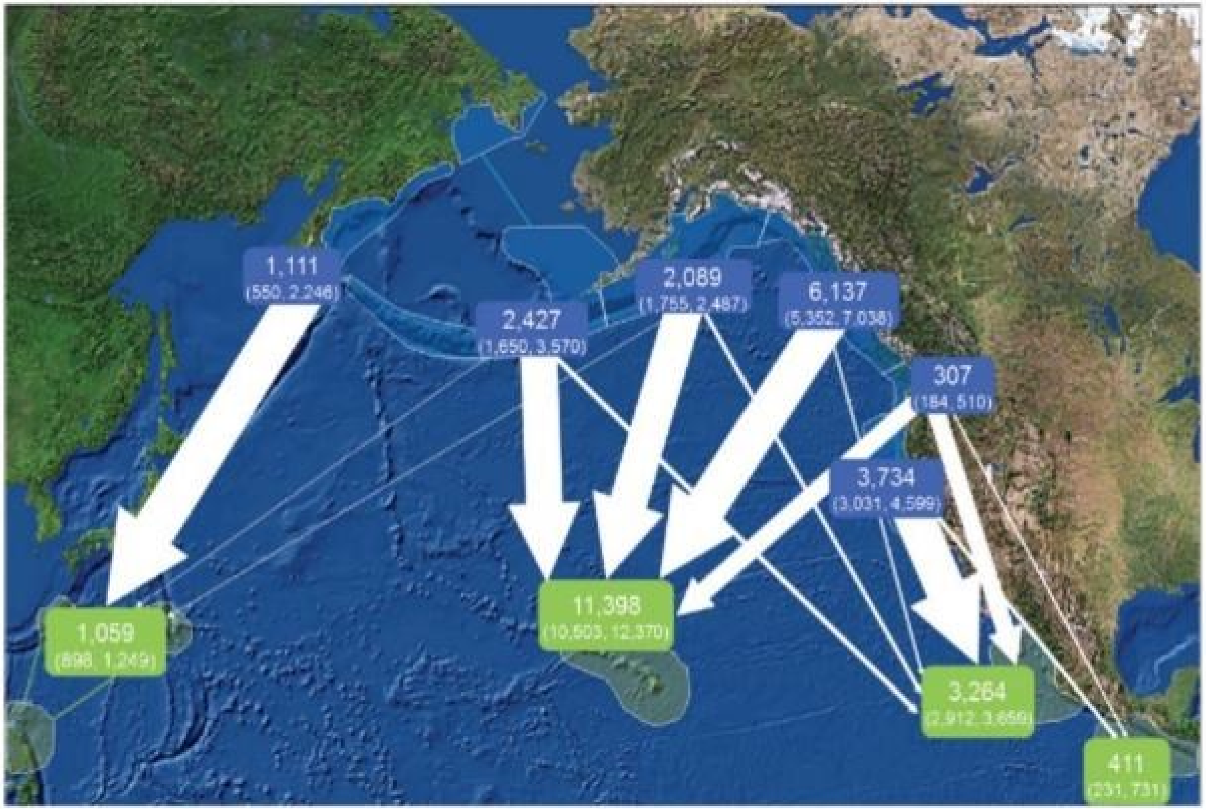

Figure 4-2. Seasonal Migrational Movements of Humpback Whales DPSs and Stocks in the North Pacific Ocean Between Summer Foraging Grounds (Blue) and Winter Breeding Grounds (Green). Estimated Humpback Whale Abundances are Presented by Area (95 Percent Log-Normal Confidence Intervals are given in Parentheses) (Wade et al., 2016).

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 humpback whales 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, 2009; 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 "megapclicks", 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.

4.1.8 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 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 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). 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 occurs within the study area for SURTASS LFA sonar and is estimated to include 922 individuals (Best et al., 2001).

Since so few North Pacific right whales exist, little information generally 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 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, 2018f; 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, 2018f). Thode et al. (2017) estimated that the source depth of North Pacific right whale vocalizations ranged from near the surface to as deep as 82 ft (25 m), water depths consistent with dive patterns of North Atlantic right whales. Dive durations ranged from 41 to 726 sec {Crance, 2017). No swim speed information is available for the North Pacific right whale except that they are known to be slow swimmers.

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 1μPa @ 1 m, with a frequency range of 90 to 170 Hz. Crance (2017) reported a sixth type of North Pacific right whale vocalization termed gunshots, which is an impulsive signal ranging from 50 Hz to 5.5 kHz with an average duration of 0.3 sec.

4.1.9 Omura's Whale (*Balaenoptera omurai)*

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 calfs 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.

4.1.10 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 3-1). 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 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 Hawaiʻi 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).

4.2 Odontocetes

Five families containing 33 species/species groups (31 species, 2 species groups) of odontocete cetaceans have been assessed for potential impacts due to the use of SURTASS LFA sonar. Odontocetes can be distinguished from mysticetes by the presence of functional teeth and a single blowhole. Odontocetes have a broad acoustic range, with mid-frequency cetaceans hearing between 150 Hz and 160 kHz and high-frequency cetaceans hearing between 260 Hz and 160 kHz (NMFS, 2016). Many odontocetes produce a variety of click and tonal sounds for communication and echolocation purposes (Au, 1993). Odontocetes communicate mainly above 1,000 Hz and produce echolocation signals as high as 160 kHz (Würsig and Richardson, 2009).

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

The Baird's beaked whales is currently classified as data deficient under the IUCN Red List of Threatened Species (Taylor et al., 2008a). 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) and 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). It was also found that one deep dive (>3,280 ft [>1,000 m]) was followed by several intermediate dives (328 to 3,280 ft [100 to 1,000 m]) (Minamikawa et al., 2007). 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 are documented.

4.2.2 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 dolpins 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 Kauaʻi/Niʻihau stock, 743 individuals in the Oʻahu 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 North Indian Ocean stock is estimated as 785,585 dolphins (Wade and Gerrodette, 1993), while 3,000 common bottlenose dolphins may occur in the waters of 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 to 110 kHz, where the threshold level range is 42 to 52 dB RL (Au, 1993). The range of highest sensitivity occurs between 25 and 70 kHz, with peaks in sensitivity at 25 and 50 kHz (Nachtigall et al., 2000). 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).

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

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 swimming up to 20 kt (37.1 kph) (Croll et al., 1999; Hui, 1987). Off California, common dolphins averaged speeds of 29 kt (9 kph) (Wiggins, 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.

4.2.4 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 which27,222 individuals are estimated to occur in the northern Indian Ocean (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.

4.2.5 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, 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, 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).

There is no direct measurement of the hearing sensitivity of Dall's porpoises (Ketten, 2000; Thewissen, 2002). It has been estimated that the reaction threshold of Dall's porpoise for pulses at 20 to 100 kHz is about 116 to 130 dB RL, but 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.

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

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., 2012 and 2013). 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, whereas dwarf sperm whales in the Gulf of California 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 auditory brainstem response 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.

4.2.7 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 proposed for the Main Hawaiian Island Insular DPS of the false killer whale (NOAA, 2017). The proposed 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, 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. Off 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).

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). 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). 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 auditory evoked potential (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).

4.2.8 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, such as 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 dolpin 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.

4.2.9 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, 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 Europe 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 (Kastelein et al., 2011). The thresholds for LF sonars were higher than for MF sonars; the measured threshold for 6-7 kHz signals was 67 dB.

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.

4.2.10 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 177-219 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).

4.2.11 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 are 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 more dives were reported during the day than at night. Fish-eating killer whales in Antarctica had shallow dives that ranged to about 656 ft (200 m), while deep dives approached 2,625 ft (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 and had dive depths of less than 16 ft (5 m). 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 top speeds of up to 20 kt (37 kph) in short bursts have been reported (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, 2009). 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 ranging 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 SLs ranged between 185 and 193 dB re 1 µPa @ 1 m. Pulse call SLs ranged between 146 and 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).

4.2.12 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. No global abundance estimate of this species is available, but 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 vocaliations. 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).

4.2.13 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; a small percentage of dives to depths less than 328 ft (100 m) while most dives were to water depths between 492 to 1,640 ft (150 and 500 m) (Joyce et al., 2017). Swim speeds for this species are not available.

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).

4.2.14 *Mesoplodon* Species

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 3-1). 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 was 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 Ocecan, 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 range in the southern Pacific Ocean and the southeastern most Indian Ocean, 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, and they have no FM structure with 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. Trains of clicks often end in a buzz. The Blainville's beaked whale has a somewhat flat spectrum that was accurately sampled between 30 and 48 kHz, with a slight decrease in the spectrum above 40 kHz, but 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).

4.2.15 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). They 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).

4.2.16 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 and that have 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.

4.2.17 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 dolphn 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).

4.2.18 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) describes pygmy killer whales producing LF “growl” sounds.

4.2.19 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). They occur predominantly in steep shelf-edge habitats, in waters 1,300 and 3,281 ft (400 and 1,000 m)deep and water temperatures commonly ranging from59° to 68° F (15° and 20° C) and rarely below 50° F (10° C) (Baird, 2009b). Seasonal migrations for 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, 1995a). 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 ± 1.7 dB for the 75 Hz pure tone signal and 140.8 dB RL ± 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.

4.2.20 Rough-toothed Dolphin (*Steno bredanensis*)

The rough-toothed dolphin is classified as least concern by the IUCN. Globally, few population estimates are available. The population of rough-toothed dolphins in the WNP stock is estimated to include 5,002 dolphins (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. They are known to skim 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. (2005) 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.

4.2.21 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). 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 Gilbraltor (Olson, 2018). 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). 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, 2009). 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, 2009) and specific call types can be repeated (Sayigh et al., 2013).

4.2.22 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 the closely related northern bottlenose whales regularly diving from 394 ft (120 m) to over 2,625 ft (800 m), with a maximum recorded dive depth to 4,770 ft (1,453 m). 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 for northern bottlenose whales have been recorded close to 70 min (Hooker and Baird, 1999). Southern bottlenose whales have been observed diving from 11 to 46 min, with an average duration of 25.3 min (Sekiguchi et al., 1993). Bottlenose whales feed primarily on squid (Gowans, 2009), and the deeper dives of northern bottlenose whales have been associated with foraging behavior (Hooker and Baird, 1999). 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.

4.2.23 Sperm Whale (*Physeter macrocephalus*)

The sperm whale is 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 equatorial waters (Whitehead, 2009). 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 maximum recorded dives to 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, 2009). 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).

4.2.24 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), while in Hawaiian waters, the Hawaii pelagic stock includes 3,351 dolphins (Barlow, 2006), and the island associated populations include the Kaua'i and Ni'ihau stock of 601 individuals, the Hawai'i 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 Hawaii 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).

4.2.25 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).

4.3 Pinnipeds

Five pinnipeds species may occur in the representative model areas for SURTASS LFA sonar (Table 3-1). Eared or otariid seals are distinguished by swimming with their foreflippers and moving on all fours on land. In contrast, true or phocid seals swim with undulating motions of the rear flippers and have a type of crawling motion on land. Otariids have ear flaps (pinnae) that are similar to carnivore ears. Phocid ears have no external features and are more water-adapted. Otariids have also retained their fur coats (Berta, 2009), whereas phocids and walruses have lost much of their fur and instead have thick layers of blubber. Many pinniped populations today have been reduced by commercial exploitation, incidental mortality, disease, predation, and habitat destruction (Bowen et al., 2009). Pinnipeds were hunted for their furs, blubber, hides, and organs. Some stocks have begun to recover. However, populations of species such as the northern fur seal and the Steller sea lion continue to decline (Gentry, 2009a).

Hearing capabilities and sound production are highly developed in all pinniped species studied to date. Pinnipeds hear both underwater and in air. Phocids hear underwater at frequencies from 50 Hz to 86 kHz, whereas otariids hear from 60 Hz to 39 kHz (NMFS, 2016). It is assumed that pinnipeds rely heavily on sound and hearing for breeding activities and social interactions (Berta, 2009; Frankel, 2009; Schusterman, 1978).

4.3.1 Otariids

4.3.1.1 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]) lasted 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. (2015) 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, 2009). 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).

4.3.1.2 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. 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 Stellers, 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.

4.3.2 PHOCIDS

4.3.2.1 Hawaiian Monk Seal (*Monachus 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, 2015b). 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, 2015b). 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, 2011b and 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, 2011b), 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) model 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., 2017b). 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).

4.3.2.2 Ribbon Seal (*Phoca 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 this species. 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.

4.3.2.3 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 inicluding growls, drums, snorts, chirps, and barks that ranged in frequency from 500 Hz to 3.5 kHz (Richardson et al., 1995).

5 TYPE OF INCIDENTAL TAKE AUTHORIZATION REQUESTED

Requirement 5: Type of incidental take authorization that is being requested (i.e., takes by harassment only; takes by harassment, injury, and/or death) and the method of incidental taking.

Pursuant to Section 101 (a)(5)(A) of the MMPA of 1972, as amended (16 USC 1371), the Navy is applying for rulemaking and a LOA for the use of SURTASS LFA sonar within the western and central North Pacific and eastern Indian oceans. The MMPA directs the Secretary of Commerce to allow, upon request, the incidental, but not intentional taking of marine mammals by U.S. citizens who engage in a specified activity (other than commercial fishing). The issuance occurs when the Secretary, after notice has been published in the *Federal Register* and opportunity for comment has been provided, finds that such takes would have a negligible impact on the species and stocks of marine mammals and would not have an unmitigable adverse impact on their availability for subsistence uses.

Marine mammals have the potential to be incidentally harassed by the underwater sound generated during the use of SURTASS LFA sonar. As a result, the Navy is requesting rulemaking under the MMPA and a LOA for the taking of marine mammals by Level B harassment incidental to the use of SURTASS LFA sonar for training and testing within the western and central North Pacific and eastern Indian oceans. No Level A incidental harassment or lethal taking is requested since the conservative mitigation zone around the transmitting sonar and the suite of other mitigation and monitoring measures employed during use of LFA sonar onboard all vessels, the sonar's operational parameters, and the geographic restrictions governing the operation of SURTASS LFA sonar preclude any reasonably foreseeable injury or mortality to potentially occurring marine mammals. Throughout the more than sixteen years of the Navy's use of SURTASS LFA sonar, no injury or mortality has ever been documented or reported to have occurred as a result of LFA sonar transmissions.

6 INCIDENTAL TAKES

Requirement 6: Age, sex, and reproductive condition (if possible), the number of marine mammals (by species) that may be taken by each type of taking identified in paragraph (a)(5) of this section, and the number of times such takings by each type of taking are likely to occur.

Potential impacts to marine mammals from the use of SURTASS LFA sonar should be assessed in the context of the basic operational characteristics of the system:

- SURTASS LFA sonar equipped vessels are U.S. Coast Guard certified for operations. In addition, these vessels would operate in accordance with all applicable federal and U.S. Navy rules and regulations related to environmental compliance. SURTASS LFA sonar vessel movements are not unusual or extraordinary and are in line with routine operations of seagoing vessels. Therefore, there should be no unregulated environmental impacts from the SURTASS LFA sonar vessels.
- At-sea activities would be temporary in nature. SURTASS LFA sonar would transmit 496 transmission hours in years 1 to 4 and 592 transmission hours in year 5 and continuing into the foreseeable future, regardless of the number of SURTASS LFA sonar equipped vessels.
- The maximum duty cycle (ratio of sound "on" time to total time) of SURTASS LFA sonar is 20 percent. However, the typical duty cycle, based on historical LFA operational parameters since 2003, is nominally 7.5 to 10 percent. That is, 7.5 to 20 percent of the time, SURTASS LFA sonar could be transmitting while 80 to 92.5 percent of the time SURTASS LFA sonar would not be transmitting, thus adding no sound into the water.
- Wavetrains last between 6 and 100 sec with an average length of 60 sec.
- The typical LFA sonar signal is not a constant tone. The duration of each continuous frequency sound transmission is no longer than 10 sec.
- The source frequency is between 100 and 500 Hz.
- The SL of an individual source projector of the SURTASS LFA sonar array is approximately 215 dB re 1 µPa @ 1 m SPL or less. As measured by SPL, the sound field of the array can never be higher than the SL of an individual source projector.

The types of potential impacts on marine mammals from SURTASS LFA sonar can be broken down into several categories:

- **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. There is very little potential for these impacts from SURTASS LFA sonar activities and no injury or mortality is requested as part of this application.
- **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., 2004). 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 other 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 [NRC], 2005).

6.1 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, 2017a) and related conclusions are incorporated by reference herein.

No new data have emerged to contradict any of the assumptions or conclusions in previous LFA sonar 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 transmissions 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.

6.2 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 (Finneran, 2015; NMFS, 2016). 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. 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. The detailed descriptions and information on auditory impacts provided in previous documentation for SURTASS LFA sonar (DoN, 2007, 2012, 2017a) are incorporated by reference herein.

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 would 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).

NMFS (2016) 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 RLs, 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 (Finneran, 2015; NMFS, 2016). 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 6-1). These weighting functions are applied to individual sound received levels to reflect the hearing ability of each species to process received acoustic energy.

NMFS (2016) defined acoustic threshold levels at which PTS is predicted to occur for each hearing group for impulsive and non-impulsive signals. SURTASS 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 functional hearing group (Figure 6-1; Table 6-1), 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 6-1).

6.3 Behavioral Change

The primary potential impact on marine mammals from exposure to SURTASS LFA sonar is change in a biologically significant behavior. NRC (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 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 would 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

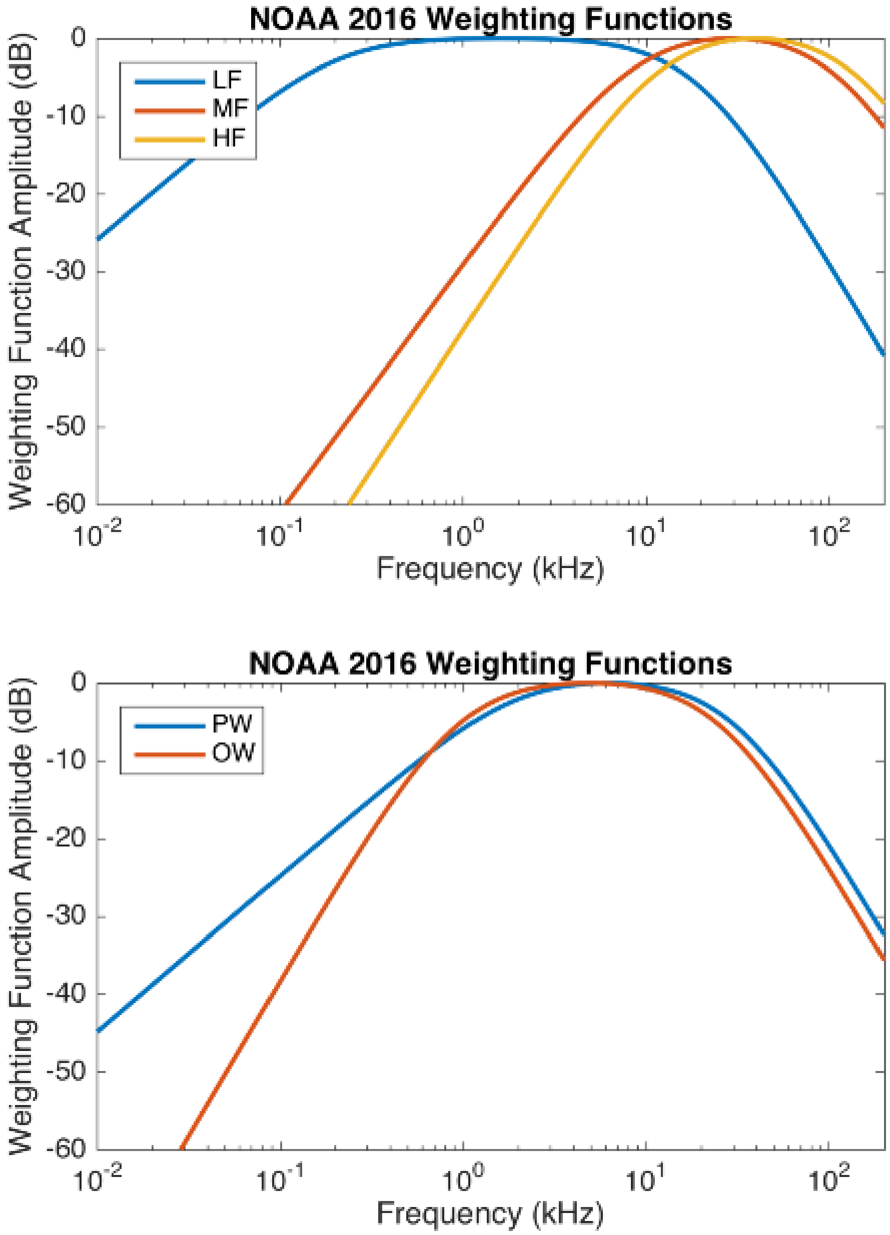

Figure 6-1. Auditory Weighting Functions for Cetaceans (Top Panel: LF, MF, and HF Species) and Pinnipeds (Bottom Panel: PW, OW) (NMFS, 2016).

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

Table 6-1. PTS and TTS Acoustic Threshold Levels for Marine Mammals Exposed to Non-impulsive Sounds (NMFS, 2016).

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

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 et al., 2001). Perhaps the most important result came from the LFS SRP Phase II study, where the LFA sonar stimulus was presented to migrating gray whales. When the source was in the migratory path, the whales diverted around the source at received 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 sonar 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, and 2012 NEPA documntation for SURTASS LFA sonar (DoN, 2001, 2007, 2012, 2017a), which as previously noted are incorporated by reference. The LFA 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 6-2).

The parameters of the risk continuum function are based on the LFS SRP results. 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

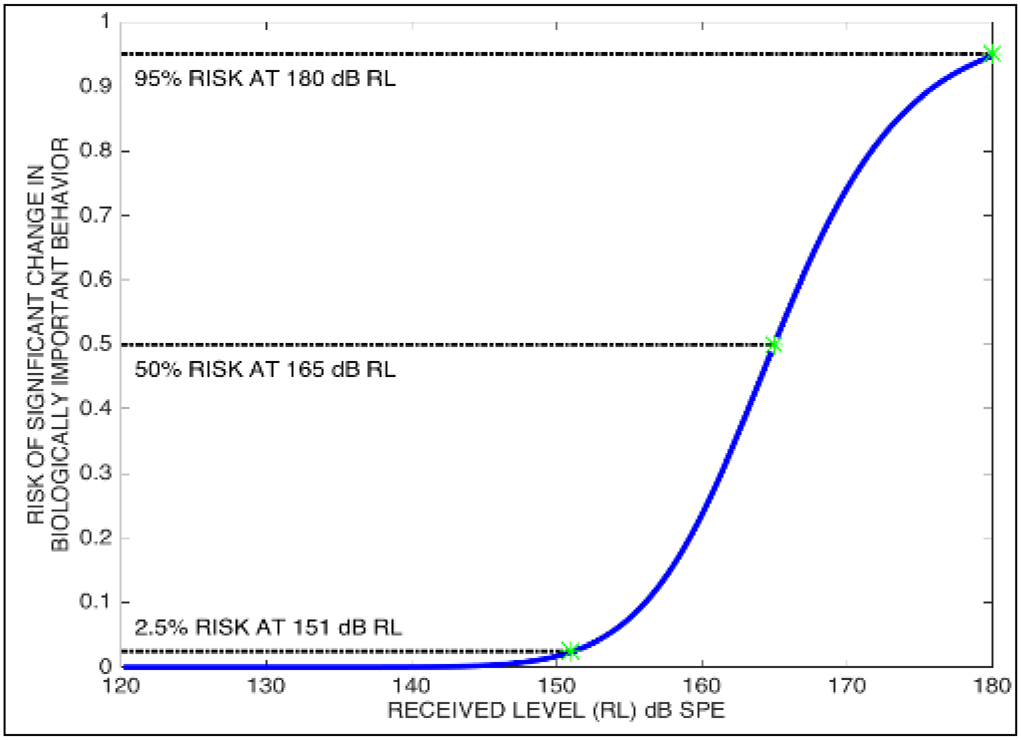

Figure 6-2. Risk Continuum Function for SURTASS LFA Sonar Analysis that Relates the Risk of Significant Change in Biologically Important Behavior to Received Levels in Decibels Single Ping Equivalent (SPE).

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. 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.

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 (MF) 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 sound exposure. Moretti et al. (2014) examined historical records of MF sonar operations and the vocal behavior of Blainville's beaked whales and were able to describe the probability of the beginning of a Group Vocal Period as a function of the received level of operational MF 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 MF 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 MF 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 RL at the animal was 98 dB re 1 µPa, and at this level the whale approached the sound source. When the RL 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 sounds, 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 RL 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 risk continuum 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. Miller et al. (2014) 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 to 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 to 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 simualted 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 RL 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., 2015a). The second whale was presented with a complex series of sweeps and tone between 3.5 and 4.05 kHz with a maximum SL 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 RL 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 Kaua‘i, 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 SL, than reported from the Phase III of the LFS SRP, even though OAWRS had a lower RL (88 to 110 dB re 1 µPa) than the LFA sonar 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).

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-sec 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-sec, 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 LFA 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.

6.4 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 effect or Lombard reflex. The source levels of vocalizations by 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 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 operation, the source is active only 7.5 to 10 percent of the time, with a maximum of 20 percent duty cycle, which means that for 80 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.

6.5 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 responses to costs at the individual level that may have repercussions 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-capture 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 modifications 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.

6.6 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, 2017a), 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.

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 3-1). 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. Winter (December, January, and February) in the southern hemisphere is 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).

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 (2016) 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). 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, and the model areas in which each activity is expected to occur (Table 6-2), 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 were evenly distributed across model areas 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 requirea 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 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. These maximum impacts per activity are summed across the stocks for Years 1 to 4 (Table 6-3) and Years 5 and beyond (Table 6-4).

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:

$$0.68\ \frac{takes}{transmission\ hr}\ x\ 72\frac{transmssion\ hr}{mission\ area}\ x\ 2\ mission\ areas = 97.92\ takes$$

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 hoursare 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 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 in Years 1 to 4 (Table 6-3) and Years 5 and beyond (Table 6-4). 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.

The potential for PTS (MMPA Level A) is considered within the context of the mitigation and monitoring efforts that would occur whenever SURTASS LFA sonar is transmitting (Chapter 5). Mitigation monitoring is designed to detect marine mammals before they are exposed to 180 dB SPL RLs. The NMFS (2016) 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.

Table 6-2. Activities and Maximum Transmission Hours Per Year Expected in each of the 15 Representative Model Areas.

Model Area Number/Name	*Activity (Transmission Hours Per Year)*					
	Contractor Crew Training (80)	*MILCREW Training (96)*	*Navy Exercise Support (96)*	*Maintenance (64)*	*Acoustic Research Testing (160)*	*Years 5+: New LFA Sonar 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		X			X	X
9 /Offshore Japan (10 to		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

Table 6-3. Maximum Total Annual MMPA Level B Harassment Requested for Years 1 to 4 by SURTASS LFA Sonar (Species and Stocks Listed Alphabetically).

Marine Mammal Species	*Stock*[9]	*Maximum Annual MMPA Level B Harassment: 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%

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

Table 6-3. Maximum Total Annual MMPA Level B Harassment Requested for Years 1 to 4 by SURTASS LFA Sonar (Species and Stocks Listed Alphabetically).

Marine Mammal Species	***Stock[9]***	***Maximum Annual MMPA Level B Harassment: 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	220.27	3.23%	3,058	43.73%	3,278	46.97%
	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 6-3. Maximum Total Annual MMPA Level B Harassment Requested for Years 1 to 4 by SURTASS LFA Sonar (Species and Stocks Listed Alphabetically).

Marine Mammal Species	*Stock*[9]	*Maximum Annual MMPA Level B Harassment: 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%
	Northwestern Hawaiian Islands	0.00	0.00%	0	0.00%	0	0.00%

Table 6-3. Maximum Total Annual MMPA Level B Harassment Requested for Years 1 to 4 by SURTASS LFA Sonar (Species and Stocks Listed Alphabetically).

Marine Mammal Species	***Stock[9]***	***Maximum Annual MMPA Level B Harassment: 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)	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%
	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 6-3. Maximum Total Annual MMPA Level B Harassment Requested for Years 1 to 4 by SURTASS LFA Sonar (Species and Stocks Listed Alphabetically).

Marine Mammal Species	***Stock***[9]	***Maximum Annual MMPA Level B Harassment: 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%

Table 6-3. Maximum Total Annual MMPA Level B Harassment Requested for Years 1 to 4 by SURTASS LFA Sonar (Species and Stocks Listed Alphabetically).

Marine Mammal Species	*Stock*[9]	*Maximum Annual MMPA Level B Harassment: 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 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%
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%

Table 6-3. Maximum Total Annual MMPA Level B Harassment Requested for Years 1 to 4 by SURTASS LFA Sonar (Species and Stocks Listed Alphabetically).

Marine Mammal Species	***Stock*[9]**	***Maximum Annual MMPA Level B Harassment: Years 1 to 4***					
		Behavior (Individuals)	***Behavior (Percent Stock)***	***TTS (Individuals)***	***TTS (Percent Stock)***	***Total Level B (Individuals)***	***Total Level B (Percent Stock)***
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 6-4. Maximum Total Annual MMPA Level B Harassment Requested for Years 5 and Beyond by SURTASS LFA Sonar (Species and Stocks Listed Alphabetically).

Marine Mammal Species	***Stock***[10]	***Maximum Annual MMPA Level B Harassment: 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%

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

Table 6-4. Maximum Total Annual MMPA Level B Harassment Requested for Years 5 and Beyond by SURTASS LFA Sonar (Species and Stocks Listed Alphabetically).

Marine Mammal Species	*Stock[10]*	*Maximum Annual MMPA Level B Harassment: 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	302.27	4.43%	4,204	60.13%	4,507	64.57%
	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%

Table 6-4. Maximum Total Annual MMPA Level B Harassment Requested for Years 5 and Beyond by SURTASS LFA Sonar (Species and Stocks Listed Alphabetically).

Marine Mammal Species	***Stock***[10]	***Maximum Annual MMPA Level B Harassment: 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 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%
	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%

Table 6-4. Maximum Total Annual MMPA Level B Harassment Requested for Years 5 and Beyond by SURTASS LFA Sonar (Species and Stocks Listed Alphabetically).

Marine Mammal Species	***Stock[10]***	***Maximum Annual MMPA Level B Harassment: 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)	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%
	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%

Table 6-4. Maximum Total Annual MMPA Level B Harassment Requested for Years 5 and Beyond by SURTASS LFA Sonar (Species and Stocks Listed Alphabetically).

Marine Mammal Species	***Stock[10]***	***Maximum Annual MMPA Level B Harassment: Years 5+***					
		Behavior (Individuals)	***Behavior (Percent Stock)***	***TTS (Individuals)***	***TTS (Percent Stock)***	***Total Level B (Individuals)***	***Total Level B (Percent Stock)***
Northern right whale dolphin	NP	0.36	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%
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%

Table 6-4. Maximum Total Annual MMPA Level B Harassment Requested for Years 5 and Beyond by SURTASS LFA Sonar (Species and Stocks Listed Alphabetically).

Marine Mammal Species	*Stock[10]*	*Maximum Annual MMPA Level B Harassment: Years 5+*					
		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 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%
	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%

Table 6-4. Maximum Total Annual MMPA Level B Harassment Requested for Years 5 and Beyond by SURTASS LFA Sonar (Species and Stocks Listed Alphabetically).

Marine Mammal Species	***Stock[10]***	***Maximum Annual MMPA Level B Harassment: Years 5+***					
		Behavior (Individuals)	***Behavior (Percent Stock)***	***TTS (Individuals)***	***TTS (Percent Stock)***	***Total Level B (Individuals)***	***Total Level B (Percent Stock)***
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%

7 IMPACTS TO MARINE MAMMAL SPECIES OR STOCKS

Requirement 7: Anticipated impact of the activity upon the species or stocks.

Acoustic analyses were conducted to determine the potential impacts to marine mammals at both the individual level and at the population level associated with exposure to SURTASS LFA sonar transmissions. The take request for MMPA Level B incidental harassment reflects a a representative number of anticipated SURTASS LFA sonar transmission hours in years 1 to 4 and years 5 and beyond at each model area. From those analyses, the maximum number of individuals potentially affected and the maximum percentage of the population potentially affected in one year were identified (Tables 6-3 and 6-4, respectively).

Level A harassment can result from auditory or non-auditory injury. Auditory injury includes 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. The NMFS (2016) guidance specifies auditory-weighted (SEL_{cum}) thresholds for the onset of PTS, which is considered as the onset of injury (Table 6-1). As stated previously, based on simple spherical spreading (i.e., TL based on $20 \times \log_{10}$ [range {m}]), all hearing groups except LF cetaceans would need to remain within 22 ft (7 m) for an entire LFA sonar ping (60 sec) to potentially experience PTS. LF cetaceans would need to remain at the greatest distance, 135 ft (41 m), from the transmitting sonar for an entire LFA sonar ping (60 sec) before experiencing the onset of injury.

The NMFS (2016) acoustic guidance was used in analysis and modeling to assess the potential for Level A harassment or auditory injury to marine mammals resulting from use of the SURTASS LFA sonar. Fifteen representative, real-world marine environments were selected for analysis and modeling. The comprehensive modeling and analysis has resulted in no (0 percent) estimated risk of MMPA Level A harassment for any marine mammal species or stocks, based on the full suite of mitigation measures being implemented when SURTASS LFA sonar is transmitting.

Non-auditory injury or Level A harassment may be possible as the result of 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. Physical impacts, such as direct acoustic trauma or acoustically enhanced bubble growth, require relatively intense received energy that would only occur at short distances from high-powered sonar sources (Nowacek et al., 2007; Zimmer and Tyack, 2007). While resonance can occur in marine animals, this resonance does not necessarily cause injury, and any such injury is not expected to occur below the received levels at which auditory injury (PTS) may occur. Damage to the lungs and large sinus cavities of cetaceans from air space resonance is not regarded as a likely significant non-auditory injury because resonance frequencies of marine mammal lungs are below that of the LFA sonar signal (Finneran, 2003). No non-auditory or Level A harassment are reasonably expected as the result of exposure to LFA sonar signals.

To date, no strandings of marine mammals have been associated with the use of SURTASS LFA sonar since its use began in the early 2000s. Use of SURTASS LFA sonar, with the comprehensive suite of mitigation measures implemented, have produced no known lethal removal impacts (i.e., Level A takes) to marine mammal stocks or species as reported in the DoN Annual Reports from 2003 through 2017. In summary, for the reasons listed above, the Navy has concluded that the likelihood of SURTASS LFA sonar transmissions (with mitigation measures implemented) causing injury or Level A harassment in marine mammals is considered negligible.

The primary impact anticipated from SURTASS LFA sonar transmission is MMPA Level B harassment of marine mammals. This Rulemaking and LOA application assumes that short-term, non-injurious sound exposures that may cause temporary threshold shifts (TTS) or temporary behavioral disruptions constitute Level B incidental harassment. Behavioral reactions of marine mammals to underwater sound are known to occur, but they are very difficult to predict. The potential behavioral impacts predicted here are based on the best available scientific data, which included a research program (LFS SRP) that exposed baleen whales to SURTASS LFA sonar while they were engaged in biologically important behaviors (blue and fin whales foraging off the U.S. west coast, gray whales migrating along the U.S. west coast, and humpback whales singing off the Hawaiian Islands). 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. The LFS SRP results also showed that the context of an exposure scenario is clearly important for determining the probability, magnitude, and duration of a response (Ellison et al., 2012).

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, eleven stocks in years 1 to 4 and fifteen 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 233.84% and 321.49% in years 1 to 4 and years 5 and beyond, respectively. This means that each individual in the population may react behaviorally or have 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 85.37% and 117.31% 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 the 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 MMPA Level B harassment. Since the potential Level B harassment would not involve long-term displacement or disruption of foraging, breeding, or migrations, 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 of LFA sonar above 180

dB rms would not occur in the four biologically important marine habitat areas (i.e., OBIAs) that are located within the study area.

- Based on the Navy's impact analysis results, no mortality and no injury (i.e., MMPA Level A harassment) of marine mammals may occur as a result of SURTASS LFA sonar, 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 oceanic 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 sec, 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 on marine animals.
- 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 sonar transmissions, coastal standoff range (180 dB SPL sound field restricted to 22 km [12 nmi] from shore), and OBIA restrictions (sound field produced by sonar below 180 dB RL, based on SPL modeling), would be implemented to reduce the potential for harassment to marine mammals that may be associated with exposure to SURTASS LFA sonar.

Consideration of negligible impact is required for NMFS to authorize incidental take of marine mammals. By definition, an activity has a "negligible impact" on a species or stock when ''an impact resulting from the specified activity that cannot be reasonably expected to, and is not reasonably likely to, adversely affect the species or stock through impacts on annual rates of recruitment or survival'' (50 CFR 216.103). The Navy has concluded that the incidental taking of marine mammals by the use of SURTASS LFA sonar would have a negligible impact on the affected marine mammal stocks or species of marine mammals.

8 IMPACT ON SUBSISTENCE USE

Requirement 8: Anticipated impact of the activity on the availability of the species or stocks of marine mammals for subsistence uses.

SURTASS LFA sonar would not be operated in Arctic waters nor in the Gulf of Alaska or off the Aleutian Island chain where subsistence uses of marine mammals occurs. Therefore, there would be no impact on subsistence hunting, nor would SURTASS LFA sonar cause abandonment of any harvest/hunting locations, displace any subsistence users, or place physical barriers between marine mammals and the hunters. No mortalities of marine mammals have been associated with the use of SURTASS LFA sonar and the Navy undertakes a suite of mitigation measures whenever SURTASS LFA sonar is actively transmitting. Therefore, the possible future use of SURTASS LFA sonar would not lead to unmitigatable adverse impacts on the availability of marine mammal species or stocks for subsistence uses.

9 IMPACT TO MARINE MAMMAL HABITAT

Requirement 9: Anticipated impact of the activity upon the habitat of the marine mammal populations, and the likelihood of restoration of the affected habitat.

9.1 Physical 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 in line with routine operations of seagoing vessels. Therefore, no discharges of pollutants regulated under the APPS or CWA would result from the operation of the sonar systems nor would unregulated environmental impacts from the operation of the SURTASS LFA sonar vessels occur.

9.2 Sound in the Environment

Use of the sonar systems results in no physical alterations to the marine environment other than the addition of sound energy to the oceanic ambient noise environment, which may have some impact on marine mammals. Anthropogenic sources of ambient noise that are most likely to have contributed 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). Hildebrand (2005) concluded that increases in anthropogenic oceanic sound sources most likely to contribute to increased noise in order of importance are: commercial shipping, offshore oil and gas exploration and drilling, and naval and other uses of sonar.

The potential impacts of SURTASS LFA sonar on the overall oceanic ambient noise level are reviewed in the following contexts:

- Recent reports on ambient sound levels in the world’s oceans;
- Operational parameters of the SURTASS LFA sonar system;
- Contribution of SURTASS LFA sonar to oceanic noise levels relative to other human-generated sources of oceanic noise; and
- Cumulative impacts from LFA sonar activities concurrent with other anthropogenic sources.

9.2.1 Oceanic Noise Levels

Ambient noise is the typical or persistent background noise that is part of an environment. Ambient noise is produced by both natural and anthropogenic (man-made) 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 and biologically-produced sounds are the two primary contributors of natural ambient sound over the frequency range of 300 Hz to 5 kHz. The sound produced by propulsion systems of ocean-going ships, with frequencies centered in the frequency range of 20 to 200 Hz, is the dominate source of anthropogenic sound in the ocean (Tyack, 2008).

In the Indian Ocean, LF (5 to 115 Hz) sounds have increased 2 to 3 dB over the past decade, while acoustic measurements in the Northeast Pacific Ocean indicate that LF (10 to 100 Hz), deep water ambient sound levels have been rising for the last 60 years (Miksis-Olds and Nichols, 2016). 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, 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 range of 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).

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 1950s and 1960s (Andrew et al., 2011). Better design of propulsion systems and economic conditions affecting the price of oil were some factors that may contribute to this reduced rate of increase in oceanic noise levels (Chapman and Price, 2011).

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 contribute to the overall ocean soundscape, including noise from oil and gas exploration, seismic airgun activity, and renewable energy sources (e.g., wind farms) (Miksis-Olds et al., 2013). Many of these anthropogenic sources are located along well-traveled shipping routes and encompass coastal and continental shelf waters, areas that are important marine habitats (Hildebrand, 2009).

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 the wind farms is more persistent and of long duration. Anthropogenic noise generated by seismic exploration is transient in nature, but 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).

The impacts that climate change may have on our ocean continue to be understood in relation to observed ocean ambient noise trends. It’s important to consider components of the ocean soundscape such as noise from changing ice dynamics and other yet-to-be-identified changes in natural sound source producing mechanisms in relation to ocean sound levels. Global climate change is projected to impact the frequency, intensity, timing, and distribution of hurricanes and tropical storms, which would also affect the ocean soundscapes on many levels (Miksis-Olds and Nichols, 2016).

Ocean acidification and its potential impact on ocean noise via changes in the acoustic absorption coefficient at low frequencies has become a subject of worldwide concern. Ocean acidification, due to the decrease of pH in the ocean from an increase in dissolved CO_2, would affect sound absorption, which has a strong dependency on pH at frequencies less than 2 kHz (Joseph and Chiu, 2010). 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).

In parts of the North Atlantic Ocean, for example, a conservative estimate is that LF sound absorption has decreased over 15 percent at 440 Hz from the pre-Industrial Revolution until the 1990s, with a greater than 10 percent decrease common above 1,312 ft (400 m) in the Pacific and Atlantic oceans (Hester et al., 2008). While these decreases in LF absorptivity represent truly immeasurably small changes, to try and resolve the uncertainty regarding the amount noise levels could increase due to these changes in sound absorption, some researchers have tried to calculate and quantify changes in ambient noise levels. Joseph and Chiu (2010) reported an expected increase of 0.2 dB for a scenario that has a surface pH change of 0.7 over the years from 1960 to 2250 in the frequency range of 50 to 2,000 Hz. Reeder and Chiu (2010) 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. Last, Ilyina et al. (2010) 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 would decrease by almost half in regions of the world’s oceans with significant anthropogenic noise, such as the North Atlantic Ocean. However, because sound absorption is a very small factor in acoustic propagation at low frequencies, the impact of these changes in absorption are likely to be so vanishingly small as to be insignificant (i.e., less than 1 dB).

9.2.2 SURTASS LFA Sonar Combined with Other Human-Generated Sources of Oceanic Noise

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 impact on the overall noise levels in the ocean would 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. In the proposed activity, the Navy would transmit SURTASS LFA sonar for up to a total of 496 hr in years 1-4 and 592 hr in year 5 and into the foreseeable future. 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 3.7×10^{12} Joules of acoustic energy into the marine environment each year (Joules/yr); seismic airguns were estimated to contribute 3.9×10^{13} Joules/yr; and mid-frequency military sonar was estimated to contribute 2.6×10^{13} Joules/yr (Hildebrand, 2005). Scaling the calculations in Hildebrand (2005) to account for the proposed transmission hours, the contribution from 496 hours of LFA sonar transmissions would be 2.0×10^{11} Joules/yr and the contribution from 592 hours of LFA sonar transmissions would be 2.3×10^{11} Joules/yr. The percentage of the total anthropogenic acoustic energy budget added by LFA sonar source transmissions is estimated to be 0.29 and 0.34 percent, respectively, for years 1-4 and year 5 and beyond (Hildebrand, 2005). Therefore, within the existing ocean environment, the potential for accumulation of noise due to the intermittent transmission of SURTASS LFA sonar is considered negligible.

9.3 Protected Marine 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. Due to their importance as marine mammal habitat, two types of marine habitats protected under U.S. legislation or Presidential EO are considered here. These marine habitats include critical habitat designated under the ESA and marine protected areas (MPAs) designated under the National Marine Sanctuaries Act and EO 13158.

9.3.1 ESA Critical Habitat

The ESA, and its amendments, require the responsible agencies of the Federal government to designate critical habitat for any species that it lists under the ESA. 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.

Of the marine mammals that have been listed as threatened or endangered under the ESA, critical habitat has been designated for one species, the Hawaiian monk seal, and proposed for another species, the Main Hawaiian Island (MHI) Insular DPS of the false killer whale, within the LFA sonar study area. 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, 2015c). 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, 2015c). 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. Thus, the portion of the critical habitat that extends beyond the coastal standoff distance is protected as an OBIA, wherein LFA sonar RLs cannot exceed 180 dB re 1 µPa (rms) SPL within 1 km (0.5 nmi) of the OBIA boundary.

Critical habitat has been proposed for the Main Hawaiian Island Insular DPS of the false killer whale (NOAA, 2017). The proposed 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, 2017).

The biological and/or physical features of the designated marine critical habitat of these species or DPSs are a combination of characteristics most relevant to the conservation of each species or DPS. The key biological and/or physical features of the marine neritic and pelagic critical habitat of the Hawaiian monk seal and Main Hawaiian Island Insular DPS 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
    - low human disturbance
    - low levels of anthropogenic noise such that the ability to detect, interpret, and utilize acoustic cues would not be affected.

The transmission of LF sound by SURTASS LFA sonar is the one aspect of SURTASS LFA sonar activities that may affect critical habitat. However, since the critical habitat designation for the MHI Insular DPS of the false killer whale has not yet been finalized, the exact definition of the physical and biological features that are essential for their conservation remains uncertain. Until the designation is finalized, the Navy is unable to determine adequately the potential effects, if any, that SURTASS LFA sonar activities may have on the proposed critical habitat of the Main Hawaiian Island Insular DPS of false killer whales.

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 critical habitat features of water quality, bathymetry, and physical circulation processes would not be affected by the operation of SURTASS LFA sonar.

Deployment and use of the SURTASS LFA sonar systems results in no physical alterations to the marine environment other than the addition of ephemeral sound energy to the oceanic ambient noise environment only when the sonar is transmitting. 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). Hildebrand (2005) concluded that increases in anthropogenic oceanic sound sources most likely to contribute to increased noise in order of magnitude are commercial shipping, offshore oil and gas exploration and development, and naval and other sonar. 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.

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 and the availability of reproductive partners. 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 are not expected to adversely affect the biological features of the Hawaiian monk seal's designated critical habitat.

9.3.2 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).

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.

9.3.2.1 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 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."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, 2009a). Currently, about 100 Federal, state, territory, and tribal agencies manage more than 1,500 marine areas in the U.S. and its territories (NMPAC, 2009b). Two federal agencies primarily manage federally designated MPAs. The Department of Commerce’s NOAA manages national marine sanctuaries (NMS), 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, territory, and local legislation; voter initiatives; and regulations have created the plethora of 1,500 MPAs that now exist, each of which was established for a specific purpose. The resulting collection of U.S. MPAs, consisting of reserves, refuges, preserves, sanctuaries, parks, monuments, national seashores, areas of special biological significance, fishery management zones, and critical habitats, is so fragmented, unrelated, and confusing that potential opportunities for broader regional conservation through coordinated planning and management are 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 the existing 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, 2009a). The MPA classification system 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, and
- Ecological scale of protection (NMPAC, 2009a).

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.

In April 2009, the NMPAC, in collaboration with federal, state, and territory agencies, tribes, advisory committees, non-governmental organizations/associations, industry, and the public, announced the establishment of the National MPA System with its initial listing of over 200 MPAs. The list of National System MPAs contains all the mutually accepted MPAs that were nominated during the initial listing. Eligible MPAs can become part of the national system by applying to the NMPAC through their managing agency.

Federal agencies that function in the marine or aquatic environment have a responsibility under EO 13158. Section 5 of EO 13158 stipulates, "…each Federal agency whose actions affect the natural or cultural resources that are protected by MPAs shall identify such actions. To the extent permitted by law and to the maximum extent practicable, each federal agency, in taking such actions, shall avoid harm to the natural and cultural resources that are protected by an MPA."

Of the more than 200 National System MPAs, three of those listed in the National System MPAs are in the SURTASS LFA sonar study area, largely because a part or their entire seaward boundary is located beyond 12 nmi (22 km) from the coastline, and are relevant to marine mammals. These MPAs include:

- Penguin Bank area of the Hawaiian Islands Humpback Whale NMS
- Papahānaumokuākea Marine National Monument
- Pacific Remote Islands Marine National Monument

9.3.2.2 International Marine Protected Areas

Although there are several efforts to document international MPAs, no network or system of international MPAs currently exists. International MPAs encompass a very wide variety of habitat types and types of MPAs as well as a good degree of variability in the levels of protection and legal mandates associated with each MPA. It is, thus, even more difficult to compile an international list of MPAs than it is in the U.S. MPAs have been designated by nearly every coastal country of the world, and by current estimates, more than 15,000 MPAs exist globally, providing protection for 3.7 to 7.3 percent of the world's oceans (IUCN, 2017; Marine Conservation Institute, 2017; 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, some 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). The Papahānaumokuākea Marine National Monument of the U.S. is the largest MPA in the study area for SURTASS LFA sonar.

9.3.2.3 Impacts of Sonar on Marine Protected Areas

Many MPAs around the world that were established specifically to protect marine mammals have been considered during the OBIA selection process. Parts of several marine mammal MPAs are amongst the 29 OBIAs where SURTASS LFA sonar would be used such that the received sound level would be less than 180 dB re 1 µPa (rms) during biologically important seasons; four OBIAs are located in the study area for SURTASS LFA sonar. Areas such as Penguin Bank, part of the Hawaiian Islands Humpback Whale National Marine Sanctuary, have been designated as OBIAs so that these critical areas for marine mammals are restricted from SURTASS LFA sonar use.

Potential impacts on MPAs are associated solely with the transmission of LF sound by SURTASS LFA sonar. Although no potential exists 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. 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) for 496 hr in years 1-4 and 592 hr in year 5 and beyond. Therefore, there is little to no potential for impacts to MPAs or for indirect impacts to the habitat upon which marine mammals depend. In many cases, critical habitat is designated to protect foraging or reproductive areas in which marine mammals congregate for these biologically significant behaviors. SURTASS LFA sonar is unlikely to affect the prey on which animals may be foraging. Neither water quality nor the physical processes that may affect the retention of prey in a specific critical habitat area would be affected by the use of SURTASS LFA sonar.

10 IMPACTS TO MARINE MAMMALS FROM HABITAT LOSS OR MODIFICATION

Requirement 10: Anticipated impact of the loss or modification of the habitat on the marine mammal populations involved.

Use of SURTASS LFA sonar in the study area beyond 12 nmi (22 km) from land, outside of potential OBIAs, would not adversely impact the habitat of marine mammals nor result in loss or modification of marine habitat. Although SURTASS LFA sonar would not harm the marine habitat, certain mitigation measures are undertaken to further guard the resources of specific types of habitats such as OBIAs.

11 MEANS OF EFFECTING LEAST PRACTICABLE ADVERSE IMPACTS—MITIGATION MEASURES

Requirement 11: Availability and feasibility (economic and technological) of equipment, methods, and manner of conducting such activity or other means of effecting the least practicable adverse impact upon the affected species or stocks, their habitat, and on their availability for subsistence uses, paying particular attention to rookeries, mating grounds, and areas of similar significance.

Mitigation, as defined by the Council on Environmental Quality, includes measures to minimize impacts by limiting the degree or magnitude of a proposed action and its implementation. The objective of the mitigation and monitoring measures presented for SURTASS LFA sonar training and testing activities are designed to effect the least practicable adverse impact on marine mammal species or stocks and their habitats and to avoid risk of injury to marine mammals. These objectives are met by:

- Ensuring that coastal waters within 12 nmi (22 km) of shore are not exposed to SURTASS LFA sonar signal RLs ≥180 dB re 1 µPa (rms) SPL;
- Ensuring that no OBIAs are exposed to SURTASS LFA sonar signal RLs ≥180 dB re 1 µPa (rms) during biologically important seasons; and
- Minimizing exposure of marine mammals to SURTASS LFA sonar signal RLs above 180 dB re 1 µPa (rms) by monitoring for their presence and suspending transmissions when one of these animals enters this mitigation zone.

Strict adherence to these measures would minimize impacts on marine mammal stocks and species as well as on sea turtle stocks and recreational or commercial divers, swimmers, snorkelers, or fishing.

11.1 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). However, the NMFS (2016) guidance specifies auditory weighted (SEL_{cum}) values for the onset of PTS, which is considered as the onset of injury. The NMFS guidance (2016) 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 (2016) 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 (2016) defines weighted thresholds as sound exposure levels (SELs) (Table 6-1). To determine what the SEL for each hearing group would be 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, and 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 be within 22 ft (7 m) for an entire LFA sonar ping (60 sec) to potentially experience PTS. LF cetaceans would be at the greatest distance from the transmitting 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. 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 an LF cetacean would begin to experience PTS from transmitting LFA sonar. Per NOAA (2016a) 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}[11] 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 was exposed to two full pings of SURTASS LFA sonar, the resulting SPL would be 179.7 dB re 1 µPa (rms). This exposure is unlikely, as a marine mammal would have to be close to the LFA sonar array for an extended period, approximately 20 minutes, to experience two full pings. Although 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 level on which previous mitigation measures for SURTASS LFA sonar have been based, the Navy proposes to retain the current mitigation basis for SURTASS LFA sonar transmissions as the distance to the 180 dB re 1 µPa (rms) isopleth.

11.2 Mitigation Measures

11.2.1 Operational Parameters

The sound signals transmitted by the SURTASS LFA sonar source 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. The Navy is currently authorized to transmit 1,020 hours of LFA sonar transmission hours per year. In this application, the Navy is proposing to reduce the annual number of transmit hours to 496 hours of SURTASS LFA sonar transmissions in years 1 to 4 and 592 hours in year 5 and the foreseeable future.

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[11] SEL_{cum}=cumulative sound exposure level

11.2.2 Mitigation Zone

Prior to commencing SURTASS LFA sonar transmissions and during 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 wouldbe 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 sound pressure levels of 180 dB or greater) would be established. Monitoring for marine animals would be conducted within the mitigation zone.

11.2.3 Buffer Zone

In the 2002 to 2007 Final Rule for SURTASS LFA sonar under the MMPA (NOAA, 2002), NMFS added a mitigation measure to preclude the potential for injury to marine mammals from resonance impacts by establishing a 1-km (0.54-nmi) buffer shutdown zone outside of the LFA sonar 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 1-km (0.54 nmi) buffer zone be implemented. This restriction has proven to be practical, but the analysis, provided in Subchapter 2.5.1 of the SURTASS LFA Sonar FSEIS (DoN, 2007) demonstrates that it did not appreciably minimize adverse impacts below 180 dB re 1 µPa (rms) RL. Thus, the removal of this mitigation measure would not generate a change of any significance in the percentage of animals potentially affected. However, the Navy would adhere to the 1-km buffer zone if implemented by NMFS in the new Rule. Subchapter 2.5.1 of the 2007 FSEIS is incorporated herein by reference.

11.2.4 Ramp-up of High Frequency Marine Mammal Monitoring (HF/M3) Sonar

The ramp-up procedure would be implemented to ensure that there wouldbe no inadvertent exposures of marine animals in close proximity to the sonar system to RLs ≥180 dB re 1 µPa (rms) from the HF/M3 active sonar system. Prior to full-power use, the HF/M3 sonar power level would 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 be implemented at least 30 minutes prior to 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 sound pressure level may not increase once a marine mammal is detected. The ramp-up may resume once marine mammals are no longer detected.

11.2.5 LFA Sonar Suspension/Delay

During training and testing activities, SURTASS LFA sonar transmissions would be delayed or suspended if the Navy detects a marine animal entering or within the LFA sonar 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, the Navy would still operate the HF/M3 active sonar system to monitor for the presence of marine mammals in addition to conducting visual and passive acoustic monitoring for marine animals. Transmissions would be allowed to commence/resume no sooner than 15 minutes after all marine mammals/animals 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.

11.2.6 Geographic Sound Field Operational Constraints

The Navy intends to continue applying the following geographic restrictions to the use of SURTASS LFA sonar:

- SURTASS LFA sonar training and testing activities would not occur within the territorial seas of foreign nations (12 nmi [22 km]) and the SURTASS LFA sonar-generated sound field would be below RLs of 180 dB re 1 µPa (rms) (SPL) within 12 nmi (22 km) of any land (including islands);
- SURTASS LFA sonar-generated sound field wouldbe below RLs of 180 dB re 1 µPa (rms) (SPL) from the outer boundary of OBIAs that have been determined by NMFS and the Navy; and
- SURTASS LFA sonar analysts wouldestimate LFA sonar sound field RLs (SPL) prior to and during active sonar transmissions so that the distance from the LFA sonar system to the 180 dB re 1 µPa (rms) isopleth is known.

LFA sonar transmissions would be suspended or delayed to ensure that RLs above 180 dB re 1 µPa (rms) would not enter the standoff range from land or OBIAs.

11.2.6.1 Coastal Standoff Distance

The coastal standoff distance or range refers to the distance of 12 nmi (22 km) from any land wherein the sound field generated by SURTASS LFA sonar training and testing activities would not exceed 180 dB re 1 µPa (rms) SPL. This distance and sound field measure were established to lower the risk to many marine animals such as marine mammals and especially sea turtles, which aggregate in coastal waters. The Navy would continue to implement the 12 nmi (22 km) coastal standoff distance while using SURTASS LFA sonar. In addition, the Navy would not conduct SURTASS LFA sonar training and testing activities within the territorial seas of foreign nations (12 nmi [22 km]).

11.2.6.2 Offshore Biologically Important Areas (OBIAs)

Since certain areas of biological importance to marine mammals lie outside the coastal standoff range for SURTASS LFA sonar, the Navy and NMFS developed the concept of OBIAs to ensure exposure of marine mammals to SURTASS LFA sonar transmissions is minimized in areas where marine mammals conduct biologically significant behaviors (i.e., OBIAs; Chapter 2). Accordingly, the Navy would conduct SURTASS LFA sonar training and testing activities such that the LFA sonar sound field would be below RLs of 180 dB re 1 µPa (rms) at the outer (seaward) boundary of designated marine mammal OBIAs during the biologically important season specified for each OBIA.

11.2.7 Sound Field Modeling

SURTASS LFA sonar crew would estimate SURTASS LFA sonar sound field RLs (SPL) prior to and during training and testing transmissions to provide the information necessary to modify transmissions, including the delay or suspension of transmissions, so that the sound field criteria referenced in this chapter are not exceeded. Sound field limits would be estimated using near real-time environmental data and underwater acoustic performance prediction models. These models are an integral part of the SURTASS LFA sonar processing system. The acoustic models wouldhelp determine the sound field by predicting 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.

11.3 Monitoring to Prevent Injury to Marine Mammals

The Navy is required to cooperate with NMFS and other federal agencies to monitor impacts on marine mammals, 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 when SURTASS LFA sonar is being used in training and testing activities:

- **Visual monitoring** for marine mammals and sea turtles from the SURTASS LFA sonar vessel 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.

All sightings are recorded in the log and provided for the annual reports to monitor for potential long-term environmental impacts.

11.3.1 Visual Monitoring

Visual monitoring would include daytime observations for marine mammals and sea turtles from the SURTASS LFA sonar vessel. Daytime is defined as 30 minutes before sunrise until 30 minutes after sunset. Visual monitoring begins 30 minutes before sunrise or 30 minutes before the SURTASS LFA sonar is deployed. Monitoring continues until 30 minutes after sunset or until the SURTASS LFA sonar is recovered aboard the vessel. Observations would be made by personnel trained in detecting and identifying marine mammals and sea turtles from the ship's bridge using standard binoculars (7x) and the naked eye. Marine mammal biologists qualified in conducting at-sea marine mammal visual monitoring from surface vessels would train and qualify designated ship personnel to conduct at-sea visual monitoring; this training may be accomplished either in-person or via video training. The objective of these observations is to maintain a track of marine mammals (and/or sea turtles) observed and to ensure that none approach the source close enough to enter the LFA mitigation zone.

The trained visual observers would maintain a topside watch for marine mammals and sea turtles at the sea surface and observation log during SURTASS LFA sonar transmissions. The numbers and identification of observed marine mammals or sea turtles, as well as any unusual behavior, would be entered into the log. A designated ship's officer would monitor the conduct of the visual watches and would periodically review the log entries. If a potentially affected marine mammal or sea turtle would be sighted anywhere within the LFA mitigation zone , the visual observer would notify the military crew (MILCREW) officer-in-charge (OIC), 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 would determine that the animal would pass into the LFA mitigation zone, the MILCREW OIC would order the immediate delay or suspension of SURTASS LFA sonar transmissions when the animal enters the LFA mitigation zone. The visual observer would continue visual monitoring and recording until the marine mammal/sea turtle is no longer observed. SURTASS LFA sonar transmissions would only 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 would continue until the behavior returns to normal or conditions did not allow monitoring to continue.

11.3.2 Passive Acoustic Monitoring

Passive acoustic monitoring would be conducted when SURTASS is deployed, 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 that may be potentially affected by SURTASS LFA sonar, the sonar technician would notify the MILCREW OIC, who would alert the HF/M3 sonar operator and visual observers (during daylight). The delay or suspension of SURTASS LFA sonar transmissions would be ordered when the HF/M3 sonar and/or visual observation indicates the marine mammal's range is within the LFA mitigation zone. Passive acoustic sonar technicians identify the detected vocalizations to marine mammal species whenever possible. As with the other types of monitoring, passive acoustic monitoring would begin 30 min prior to the first LFA sonar transmission, continue throughout all LFA sonar transmissions, and end at least 15 minutes after LFA sonar transmissions would no longer be broadcast.

11.3.3 Active Acoustic Monitoring

HF active acoustic monitoring uses the HF/M3 sonar to detect, locate, and track marine mammals (and possibly sea turtles) that could pass close enough to the SURTASS LFA sonar array to enter the LFA mitigation zone. 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. Prior to full-power use, the HF/M3 sonar 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 to ensure that there are no inadvertent exposures of marine mammals or sea turtles to RLs ≥180 dB re 1 µPa (rms) from the HF/M3 sonar.

If a contact would be 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 when the marine mammal/sea turtle would be predicted to enter the LFA mitigation zone. SURTASS LFA sonar transmissions would commence/resume 15 minutes after there are no further detections by the HF/M3 sonar, visual, or passive acoustic within the LFA mitigation zone.

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 and 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); the LFA mitigation is the distance to the 180-dB isopleth, which is nominally 0.54 nmi (1 km), depending upon the environmental conditions, while the buffer zone imposed by NMFS is an additional 0.54 nmi (1 km). Additionally, qualitative and quantitative assessments of the HF/M3 system's ability to detect marine mammals of various sizes were verified in 170 hours of at-sea testing. The sea testing showed that several detections of a marine mammal by the HF/M3 sonar system would occur before a marine mammal entered the LFA mitigation zone (DoN, 2001). Indeed, based on the scan rate of the HF/M3 sonar system, most animals would receive at least 8 pings from the sonar (i.e., 8 sonar returns or detections) before even entering the LFA mitigation zone. Based on this, the probability of a marine mammal being detected prior to entering the 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 swimming towards the system in the LFA mitigation zone with only one HF/M3 ping would be near 100 percent (Ellison and Stein, 2001). During sea tests of the HF/M3 sonar system with trained Navy bottlenose dolphins, the detection rate of the dolphins was about 80 percent, but analysts noted that in more normal at-sea operational conditions with reduced clutter interference and dolphins traveling more typically in pods, the detection rate would be higher (Ellison and Stein, 2001).

11.4 Other Mitigation Measures Considered

The Navy considered additional mitigation measures for effecting the least practicable adverse impact upon potentially affected species or stocks, their habitat, and their availability for subsistence uses. However, when evaluated under the least practicable advserve impact standard, these measures did not reduce the likelihood or degree of adverse impacts on species or stocks or were impracticable when personnel safety, practicality of implementation, and impact on the effectiveness of the military readiness activity were considered. Discussions of previously evaluated 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, 2017a).

11.4.1 Longer Suspension/Delay Period

Navy has considered whether a longer clearance time of 30 minutes before LFA sonar transmissions are allowed to commence/resume after an animal is detected 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 under water in addition to the use of the SURTASS passive system, such a long clearance time to detect deeper diving marine mammals is not necessary. HF/M3 sonar used in combination with passive acoustic and visual mitigation monitoring would effectively detect marine mammals present in the mitigation zone within the 15 minute timeframe.

11.4.2 Restrict Transmissions to Daylight Hours

The Navy assessed the requirements for the use of SURTASS LFA sonar for the proposed training and testing activities. It is a necessity that the Navy conduct training and testing at night in addition to during daylight hours. The Navy must train and test in the same manner in which it would conduct activities during combat. Training and operating differently from what would be needed in an actual combat scenario would decrease training effectiveness, reduce crews' abilities, and introduce an increased safety risk to personnel. The operators must be capable of operating the SURTASS LFA sonar systems in all environments that may be experienced year-round, including night conditions. Training and operating at night is vital because environmental differences between day and night affect the detection capabilities of sonar. Consequently, personnel must train and operate during all hours of the day and night to ensure they identify and respond to changing environmental conditions. Avoiding or reducing active sonar at night for the purpose of mitigation would result in an unacceptable impact on military readiness.

The Navy is proposing to implement a three-part mitigation monitoring that includes active and passive acoustic monitoring in addition to visual monitoring. Therefore, while visual monitoring would not be able to occur effectively at night, passive acoustic and active acoustic monitoring would be able to occur and would be highly effective at detecting marine mammals and triggering mitigation measures (shutdown). Therefore, the mitigation measure to restrict sonar transmissions to daylight hours was eliminated from further consideration.

11.4.3 Reduce Training and Testing Activities

The Navy is currently approved to transmit 1,020 hours of LFA sonar transmissions per year. After careful consideration, the Navy is proposing to reduce its transmissions to 496 hours in the first four years and 592 hours in year five and continuing into the foreseeable future. In Section 2.1, the Navy detailed the six activities that comprise their proposed use of SURTASS LFA sonar for training and testing activities. The Navy carefully considered the amount of transmission hours that are necessary to meet its purpose and need when developing this application. The ability to operate SURTASS LFA sonar is skill that must be repeatedly practiced under realistic conditions. Training and testing during multiple conditions is critical since environmental conditions differ between day and night and varying weather conditions affect sound propagation and the detection capabilities of SURTASS LFA sonar. The Navy uses computer simulation to augment training and testing whenever possible. Computer simulation can provide familiarity and complement live training; however, it cannot provide the fidelity and level of training necessary nor replicate all possible environmental scenarios found in the real world. Therefore, the Navy would continue to use simulation to augment training and testing, but a further reduction in transmission hours would not meet the Navy's need and is eliminated from further consideration.

11.4.4 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. In summary, increasing the coastal standoff range to 25 nmi (46 km) decreased the exposures of coastal shelf species to SURTASS LFA sonar transmissions but increased the exposures of shelf break and pelagic species. 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 shelf break and pelagic species. Therefore, the Navy did not implement this option.

11.4.5 Expanded Geographic Sound Field Operational Constraints

The Navy considered reducing the SURTASS LFA sonar-generated sound field for the coastal standoff range and at the outer boundary of OBIAs 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 (2016) 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, the LFA sonar vessel is in constant motion, so any transmission within an OBIA or the coastal standoff range at levels expected to 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 buffer zones to such sizes would result in significant impacts to military readiness activities by reducing the acoustic regions in which training and testing of the SURTASS LFA sonar could occur, due to the distance the system would have to operate off these areas. Therefore, since the current suite of mitigation measures already prevent injury, most TTS, and more severe behavioral responses, the expanded geographic sound field constraints do not significantly decrease the anticipated impact and are elminated from consideration.

11.5 Summary of Mitigation Measures for SURTASS LFA Sonar Use

There are a suite of mitigation measures that apply to the use of SURTASS LFA sonar as well as three types of monitoring measures to prevent injury that comprehensively mitigate adverse impacts to marine mammals when SURTASS LFA sonar is in use (Table 11-1).

Table 11-1. Summary of Mitigation Measures for Use of SURTASS LFA Sonar.

Mitigation Measure	*Criteria*	*Actions*
Geographic Restrictions		
12 nmi (22 km) from coastline	Sound field below 180 dB RL, based on SPL modeling	Delay/suspend SURTASS LFA sonar transmissions if sound field criterion is exceeded
OBIA during biologically important seasons	Sound field below 180 dB RL, based on SPL modeling	Delay/suspend SURTASS LFA sonar transmissions if sound field criterion is exceeded
Monitoring to Prevent Injury to Marine Mammals and Sea Turtles		
Visual Monitoring	Potentially affected species near the vessel but outside of the LFA mitigation zone	Notify OIC
	Potentially affected species sighted within 1.1 nmi (2 km) and 45 degrees either side of the bow or inside of the LFA mitigation zone	Delay/suspend SURTASS LFA sonar transmissions
Passive Acoustic Monitoring	Potentially affected species detected	Notify OIC
Active Acoustic Monitoring	Contact detected and determined to have a track that would pass within the LFA mitigation zone	Notify OIC
	Potentially affected species detected inside of the LFA mitigation zone	Delay/suspend SURTASS LFA sonar transmissions

12 MINIMIZATION OF ADVERSE EFFECTS ON SUBSISTENCE USES

Requirement 12: Where the proposed activity would take place in or near a traditional Arctic subsistence hunting area and/or may affect the availability of a species or stock of marine mammals for Arctic subsistence uses, the applicant must submit either a "plan of cooperation" or information that identifies what measures have been taken and/or will be taken to minimize any adverse effects on the availability of marine mammals for subsistence uses.

SURTASS LFA sonar would not be operated in Arctic waters, nor in the Gulf of Alaska or off the Aleutian Island chain where subsistence uses of marine mammals occurs. Therefore, there would be no impact on subsistence hunting, nor would SURTASS LFA sonar cause abandonment of any harvest/hunting locations, displace any subsistence users, or place physical barriers between marine mammals and the hunters. The Navy undertakes a suite of mitigation measures whenever SURTASS LFA sonar is actively transmitting. Therefore, the use of SURTASS LFA sonar would not lead to any adverse effects on subsistence-hunted marine mammals nor would it reduce the availability of marine mammal stocks or species for subsistence uses. For this reason, a cooperation plan is not applicable to this activity.

13 MONITORING AND REPORTING

Requirement 13: The suggested means of accomplishing the necessary monitoring and reporting that will result in increased knowledge of the species, the level of taking or impacts on populations of marine mammals that are expected to be present while conducting activities and suggested means of minimizing burdens of coordinating such reporting requirements with other schemes already applicable to persons conducting such activity. Monitoring plans should include a description of the survey techniques that would be used to determine the movement and activity of marine mammals near the activity site(s) including migration and other habitat uses, such as feeding. Guidelines for developing site-specific monitoring plan may be obtained by writing to the Director, Office of Protected Resources.

13.1 Monitoring to Increase Knowledge of Affected Marine Mammal Species

In addition to the mitigation monitoring the Navy conducts during at-sea SURTASS LFA sonar activities, the Navy also conducts numerous monitoring efforts that provide information about the marine environment and marine mammal occurrence and behavior.

13.1.1 Ambient Noise Data 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. These ambient noise data, especially from areas of the ocean for which 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) that is being developed for 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. Additionally, these additional marine ambient noise data may also illustrate how noise levels in specific parts of the ocean change over time.

In acknowledgement of the valuable ambient noise 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. The Navy continues to study the feasibility of declassifying portions of these data after all related security concerns have been resolved. SURTASS LFA sonar's Marine Mammal Monitoring (M3) program is working to compile information on the ambient noise data that have been collected from various systems as a starting point for further discussions on data dissemination, either at a classified or unclassified level.

13.1.2 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 a report of fin whale singing and swimming behaviors from which a scientific paper has been submitted to a scientific journal for review (DoN, 2015). In addition, information on detections of western gray whale vocalizations has been shared with the International Union for the Conservation of Nature on possible wintering areas for this highly-endangered marine mammal. 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.

13.2 Reporting

The Navy would report on the level of SURTASS LFA sonar training and testing transmissions over annual periods, the locations in which marine mammals may have been exposed to SURTASS LFA sonar training and testing activities, the associated taking of marine mammals from those exposures 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 keep track of the level of SURTASS LFA sonar training and testing transmission hours throughout the year to ensure that the approved level of transmissions is not exceeded.

13.2.1 Incident Monitoring

Crews of the SURTASS LFA sonar vessels systematically observe the sea surface during and after SURTASS LFA sonar transmissions for injured or disabled marine mammals. The Navy 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 transmissions occurred and correlates the marine mammal strandings temporally and spatially with SURTASS LFA sonar transmissions.

Additionally, the Navy would notify NMFS immediately, or as soon as clearance procedures allow, if an injured, stranded, or dead marine mammal were found during, shortly after (within 24 hr), and in the vicinity of any SURTASS LFA sonar transmissions. In the event that an injured, stranded, or dead marine mammal is found by the SURTASS LFA sonar vessel crew during transit, or that is not in the vicinity of, or found during or shortly after SURTASS LFA sonar activities, 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 by one of the SURTASS LFA sonar vessels, including all pertinent information on the strike and associated vessel. No marine mammals have ever been struck by SURTASS LFA sonar vessels.

13.2.2 Annual and Comprehensive Reports

The Navy would submit an unclassified annual report to the NMFS Office of Protected Resources Director no later than 60 days after the anniversary of the date on which the LOA becomes effective. The annual report on SURTASS LFA sonar training and testing activities would contain summaries of the dates/times and locations of LFA sonar activity; location of the mitigation zone (i.e., distance to the 180 dB rms isopleth) in relation to the LFA sonar array; marine mammal detections from visual, passive acoustic, and active acoustic monitoring; and delays or suspensions of LFA sonar transmissions due to mitigation monitoring protocol. Marine mammal detections would include general type of marine mammals (i.e., whales, dolphins) and/or species identifications, number of marine mammals detected, time frame of detections, type of detection (visual, passive acoustic, HF/M3 sonar), bearing and range from the vessel, 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 SURTASS LFA sonar transmissions using acoustic impact modeling based on locations, seasons, system characteristics, oceanographic environmental conditions, and marine mammal demographics; estimations of total percentages of each marine mammal stock affected by all SURTASS LFA sonar transmissions during the annual period; analysis of the effectiveness of mitigation measures; estimation of cumulative impacts; and long-term effects on marine mammals from SURTASS LFA sonar transmissions.

Each annual report would build on the previous annual report to provide a cumulative overview of the level of training and testing transmission hours per year as well as estimates of total percentages of each marine mammal stock affected by SURTASS LFA sonar transmissions during each annual period. At the end of the effective period of the LOA, the final annual report would be a cumulative, comprehensive report, that is, an unclassified assessment of impacts of SURTASS LFA sonar training and testing activities on marine mammal stocks during the MMPA regulation period.

13.3 Adaptive Management

Since the understanding of the potential effects of SURTASS LFA sonar on marine mammals is continually evolving, the Navy is including an adaptive management component within the scientific framework of this application for rule-making and a letter of authorization. The adaptive management process allows NMFS, in consultation with the Navy, to modify or augment existing mitigation or monitoring measures if doing so would have a reasonable likelihood of more effectively accomplishing the mitigation and monitoring objectives of minimizing adverse impacts on marine mammals (50 CFR 218.241). Adaptive management allows the Navy and NMFS to consider, on a case-by-case basis, new peer-reviewed and published scientific data and information or survey data to determine whether consideration, practicability included, should be given to the modification of current SURTASS LFA sonar mitigation monitoring measures or the designation of additional OBIAs for SURTASS LFA sonar, if new scientific data indicate that such modifications would be appropriate. The adaptive management process also allows for updates to marine mammal stock estimates which, in turn, provide for the use of the best available scientific data for predictive models. Under the adaptive management process, the Navy and NMFS would meet annually, if deemed necessary.

14 RESEARCH

Requirement 14: *Suggested means of learning of, encouraging, and coordinating research opportunities, plans, and activities relating to reducing such incidental taking and evaluating its effects.*

The Navy sponsors significant research and monitoring projects to study the potential impacts of its activities on marine mammals. The most recently available data are for Fiscal Year 2015 in which the Navy reported that it spent $35.9 million that year on marine mammal research and conservation (Marine Mammal Commission [MMC], 2017). The survey was designed to capture information on marine mammal-related programs, projects, and grants, including the nature of the research, the species and geographic areas studied, the threats and issues addressed, and the funding amounts obligated during the fiscal year. Within the Navy, research is funded primarily by the Office of Naval Research, the Living Marine Resources (LMR) program, and the Navy's Atlantic and Pacific fleets, with about $3.5M of the $35.9M being funded by the Naval Sea Systems Command and the Naval Air Systems Command (MMC, 2017). The Navy developed an Integrated Comprehensive Monitoring Plan to ensure coordinated and efficient research and monitoring efforts within an overarching framework.

The Office of Naval Research Marine Mammals and Biology program supports basic and applied research and technology development related to understanding the impacts of sound on marine mammals, including physiological, behavioral, ecological, and population-level impacts. There are currently four program thrusts:

- Monitoring and detection (development of passive, infrared, and other technologies).
- Integrated ecosystem research (sensor and tag development).
- Impacts of sound on marine life (behavioral response studies, diving physiology, physiological stress response, hearing, population consequences of acoustic disturbance).
- Models and databases for environmental compliance.

The mission of the Navy's LMR program is to develop, demonstrate, and assess information and technology solutions to minimize the environmental risks of Navy at-sea training and testing activities while preserving core Navy readiness capabilities. The five key investment areas of LMR are: (1) data to support risk threshold criteria, (2) improved collection and processing of protected species data in areas of Navy interest, (3) monitoring and mitigation technology demonstrations, (4) standards and metrics, and (5) education and outreach, emergent opportunities.

The Navy's Marine Species Monitoring program is designed to address the Navy's research and monitoring requirements under the ESA and the MMPA across the various geographic regions where the Navy trains. Individual projects are funded after evaluation against a Strategic Planning Process that was developed with input from a science advisory group, NMFS, and other regional experts. Current projects include monitoring pinniped haul-outs and photo-identification in coastal areas of the eastern North Atlantic Ocean, humpback whale distribution in the mid-Atlantic region, cetacean occurrence in the continental shelf break region of the Virginia Capes Operating Area and U.S. west coast ranges, and behavioral response studies of marine mammals to Navy training and testing activities.

14.1 SURTASS LFA Sonar's Marine Mammal Monitoring (M3) Program

The Navy has and continues to sponsor multi-year research studies using fixed passive acoustic assets. Beginning in 1993, the M3 program was designed to assess the feasibility of detecting and tracking marine mammals using Navy assets. The M3 program has evolved into a valuable tool by which the acoustic activity levels of vocalizing whales can be quantitatively documented and trends of oceanic ambient noise levels measured over ecologically meaningful ocean scales and time periods under varying ocean noise conditions.

As part of the research component of the SURTASS LFA sonar program, M3 data are collected to: a) document occurrence, distribution, and behaviors of acoustically active whale species over ocean basin and decadal scales; b) objectively assess changes in marine mammal activity levels under normal conditions (e.g., weather, wind, time of year, or time of day) relative to acoustic conditions with varying levels of anthropogenic sources (e.g., seismic profilers[12], naval sonar, shipping, or fishing activity); c) uniquely inform environmental assessments of current and future anti-submarine warfare systems; and d) assemble a long-term database of ocean ambient noise data to enable scientifically-based evaluations of potential influences on cetaceans or other species.

Acoustic data and information collected and archived by the M3 program allow program analysts to statistically quantify how cetacean acoustic behaviors are affected by various factors, such as ocean basin topographic features, hydrographic conditions, seasonality, time, weather conditions, and ambient noise conditions. The compiled acoustic data can be used to estimate the total number of vocalizing whales per unit area, as well as document the seasonal or localized movements of individual animals. In addition, observations over time can also show the interaction and influence of noise sources on large whale behavior.

Besides documenting known sound sources, the M3 analysts use their expertise to expand the Navy's catalog of biological sounds that cannot be identified to species. This collection of unknown biologic sounds includes some signal types that are clearly from large whales, some that are most likely echolocation clicks from diving odontocetes, some that are from fishes, and some that are from invertebrates (e.g., daily vertical migrations). By authenticating that a sound source is of biological origin, the M3 program has significantly contributed to the proper identification of marine sound sources that are not of biological origin.

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[12] The term seismic profiler refers to a vessel operating a seismic airgun array or arrays as part of a geological and geophysical survey, usually to explore for sub-bottom oil and gas but also to conduct basic research.

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