APPLICATION FOR LETTERS OF AUTHORIZATION AND RULEMAKING UNDER SECTION 101 (a)(5)(A) OF THE MARINE MAMMAL PROTECTION ACT FOR ACTIVITIES ASSOCIATED WITH THE EMPLOYMENT 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 or equal to
<	less than
±	plus or minus
µ	micro (10^{-6})
4D	four-dimensional
Đ	no density available
₽	not present in season modeled
AEP	auditory evoked potential
AIM	Acoustic Integration Model
APPS	Act to Prevent Pollution from Ships
ASW	antisubmarine warfare
AUTEC	Atlantic Undersea Test and Evaluation Center
BRS	behavioral response study
C	Celsius
CITES	Convention on International Trade in Endangered Species
CLFA	compact low frequency active
CNO	Chief of Naval Operations
COTS	commercial off-the-shelf
CW	continuous wave
CWA	Clean Water Act
DASN(E)	Deputy Assistant Secretary of the Navy for Environment
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
GDEM	Generalized Digital Environmental Model
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)
M	million
M3	marine mammal monitoring
MF	mid-frequency
MFA	mid-frequency active
MILCREW	military crew
min	minute(s)
MMC	Marine Mammal Commission
MMPA	Marine Mammal Protection Act
MODAS	Modular Ocean Data Assimilation System
MPA	Marine Protected Area
NDAA	National Defense Authorization Act
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
OAML	Oceanographic and Atmospheric Master Library
OBIA(s)	offshore biologically important area(s)
OEIS/EIS	Overseas Environmental Impact Statement and Environmental Impact
OIC	Officer-in-charge
OPAREA	operating area
OW	otariid underwater
Pa	Pascal
PAM	passive acoustic monitoring
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
SEL	sound exposure level
SL	source level
SME	subject matter expert
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
XBT	Expendable bathythermograph

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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 USC 1371), the Department of the Navy (DoN; hereafter, the Navy) is applying for rulemaking and Letters of Authorization (LOAs) for the employment of Surveillance Towed Array Sensor System (SURTASS) Low Frequency Active (LFA) sonar during routine training, testing, and military operations. The MMPA directs the Secretary of Commerce (Secretary) 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) during periods of not more than five consecutive years. 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 will have a negligible impact on the species and stocks of marine mammals and will not have an unmitigable adverse impact on their availability for subsistence uses. Marine mammals will be incidentally harassed due to the underwater noise generated by the employment of SURTASS LFA sonar systems during at-sea operations. As a result, the Navy is requesting rulemaking and will request subsequent annual LOAs under the MMPA for taking of marine mammals by Level A and Level B (no lethal) harassment incidental to the employment of up to four SURTASS LFA sonar systems within the Pacific, Atlantic, and Indian oceans and the Mediterranean Sea for the five year period from August 2017 through August 2022.

This application for rulemaking and LOAs is the fourth such application the Navy has submitted to the National Marine Fisheries Service (NMFS) for employment 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 USNS IMPECCABLE. In 2006, the Navy submitted its application for the second five-year Rule under MMPA (DoN, 2006) for the taking of marine mammals by Level A and Level B harassment 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 in 2007 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 MMPA (DoN, 2011) for the taking of marine mammals by Level A and Level B harassment 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 in 2012 issued annual LOAs for sonar use on the USNS VICTORIOUS, USNS ABLE, USNS EFFECTIVE and USNS IMPECCABLE. On July 15, 2016, the Ninth Circuit issued a decision in Natural Resources Defense Council (NRDC), et al. versus Pritzker, et al., which challenged NMFS's analysis under the MMPA for the current MMPA Final Rule for SURTASS LFA sonar. The United States was still reviewing this decision at the time this application was submitted.

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 fourth request for rulemaking and LOAs are: (1) the analysis of spatial and temporal distributions of protected marine mammals in potential operating areas for SURTASS LFA sonar, (2) a review of activities that have the potential to affect marine mammals, and (3) a technical risk assessment to determine the likelihood of impacts from use of active sonar during routine training, testing, and military operations in the world’s oceans, with specific geographic areas exempted from operations.

1.2 Proposed Activity

The proposed action is Navy’s employment of up to four SURTASS LFA sonar systems in the world’s non-polar oceans for military readiness activities including routine training, testing, and military operations from August 2017 through August 2022. Potential operations could occur in the Pacific, Atlantic, and Indian oceans, and the Mediterranean Sea. The Navy will not operate SURTASS LFA sonar in Arctic and Antarctic waters. Additional geographic restrictions include maintaining SURTASS LFA sonar received levels below 180 dB re 1 µPa (root-mean-square [rms]) within 12 nautical miles (nmi) (22 kilometers [km]) of any land, and within the boundaries of designated Offshore Biologically Important Areas (OBIAs) during their effective periods of biological activity, which are identified in this application.[1]

Nominal at-sea missions for each vessel using SURTASS LFA sonar would last up to 294 days, with 240 days at sea conducting routine training, testing, and military operations and 54 days of transit. The maximum number of actual transmission hours per vessel would not exceed 255 hours (hr) annually.

For this application, the Navy has determined that marine mammals would be incidentally harassed by the acoustic signals transmitted during the employment of SURTASS LFA sonar during at-sea operations. The remainder of this chapter discusses the Navy’s SURTASS LFA sonar operations in greater detail.

1.3 Background

In 2003, 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 testing and training operations 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 employment of the SURTASS LFA sonar system, acoustic signals are introduced into the ocean environment that could potentially affect the marine environment. As a result, the Navy conducted

1 Although not germane to this LOA and rulemaking application, an additional geographic restriction is in place for the employment of SURTASS LFA sonar. The sound field produced by the sonar cannot exceed 145 decibels (dB) sound pressure level (SPL) in the vicinity of known human dive sites (most sites frequented by recreational divers generally are shallower than 40 meters (m) [130 feet (ft)]) to protect human divers.

analyses relevant to the potential environmental impacts of using the SURTASS LFA sonar system. In this application, the Navy proposes the same number (four) of surveillance vessels and SURTASS LFA sonar systems will be employed, SURTASS LFA sonar will be operated in the same manner, and the same geographic areas will be encompassed as were described in the Final Supplemental Environmental Impact Statement/Supplemental Overseas Environmental Impact Statement (FSEIS/SOEIS) for SURTASS LFA Sonar (DoN, 2012) and the Final Supplemental Environmental Impact Statement/Supplemental Overseas Environmental Impact Statement **(**FSEIS/SOEIS) for SURTASS LFA Sonar (DoN, 2015), which are both incorporated by reference herein. The current SEIS/SOEIS also builds upon the Final Overseas Environmental Impact Statement and Environmental Impact Statement (FOEIS/EIS) for SURTASS LFA Sonar (DoN, 2001) and the FSEIS for SURTASS LFA Sonar (DoN, 2007). Concurrent with the development of this application, the Navy has completed a Draft Supplemental EIS/Supplemental OEIS (DSEIS/SOEIS) (DoN, 2016a). The Navy is the lead agency and NMFS is the cooperating agency for the preparation of these documents, which have 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. For SURTASS LFA sonar, EO 12114 applies to environmental impacts outside U.S. maritime boundaries, including U.S. territories and possessions.

1.4 Purpose and Need for SURTASS LFA Sonar

The Navy's primary mission is to maintain, train, equip, and operate combat-ready naval forces capable of accomplishing American strategic objectives, deterring maritime aggression, and assuring freedom of navigation in ocean areas. This mission is mandated by Federal law (Title 10 U.S.C. §5062), which ensures the readiness of U.S. naval forces. The Secretary of the Navy and Chief of Naval Operations (CNO) have established that anti-submarine warfare (ASW) is a critical part of the Navy's mission, requiring unfettered access to both the high seas and littorals[2]. To be prepared for all potential threats, the Navy must maintain ASW core competency through continual training in open-ocean and littoral environments.

ASW is challenged by the increased difficulty in locating undersea threats solely by using passive acoustic technologies, due to the advancement and use of quieting technologies in diesel-electric and nuclear submarines. At the same time as the distance at which submarine threats can be detected decreases due to quieting technologies, improvements in torpedo and missile design have extended the effective range of these weapons.

One of the ways the Navy has addressed the changing requirements for ASW readiness was by developing SURTASS LFA sonar. SURTASS LFA sonar is able to reliably detect quieter and harder-to-find 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. SURTASS LFA sonar operates day and night in a variety of weather conditions. The active acoustic component in the SURTASS LFA sonar 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 especially by quiet, diesel submarines.

2 The Navy defines "littoral" as the region that horizontally encompasses the land/water mass interface from 50 statute miles (80 km) ashore to 200 nmi (370 km) at sea; this region extends vertically from the bottom of the ocean to the top of the atmosphere and from the land surface to the top of the atmosphere (Naval Oceanographic Office, 1999). The common meaning of littoral pertains to the shore or a coastal region, while the marine science definition refers to the shallow-water zone between low- and high-tide.

1.5 SURTASS LFA Sonar Technology

SURTASS LFA sonar systems are long-range sensors that operate in the low frequency (LF) band (i.e., below 1,000 Hertz [Hz]) and include both active and passive acoustic components (Figure 1-1). 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 (COTS) “fish finders” to military ASW systems for detection and classification of submarines.

The passive component, SURTASS, is a towed horizontal line array detection system that uses hydrophones to detect sound emitted or reflected from submerged targets. Passive sonar is a one-way transmission of sound waves traveling through the water from the source to the receiver and is basically the same as people hearing sounds that are created by another source and transmitted through the air to the ear. The active component of the system, LFA, is comprised of a set of acoustic transmitting source elements suspended by cable beneath certain ocean surveillance ships. Active sonar detects objects by creating a sound pulse or “ping” that is transmitted through the water and reflects off the target, returning in the form of an echo. This is a two-way transmission (source to reflector to receiver). Echolocation, by which some marine mammals locate prey and navigate, is a form of active sonar. SURTASS LFA sonar systems operate within the frequency range of 100 to 500 Hz. The LFA sonar component is an augmentation to the SURTASS component and is used when passive system performance is inadequate.

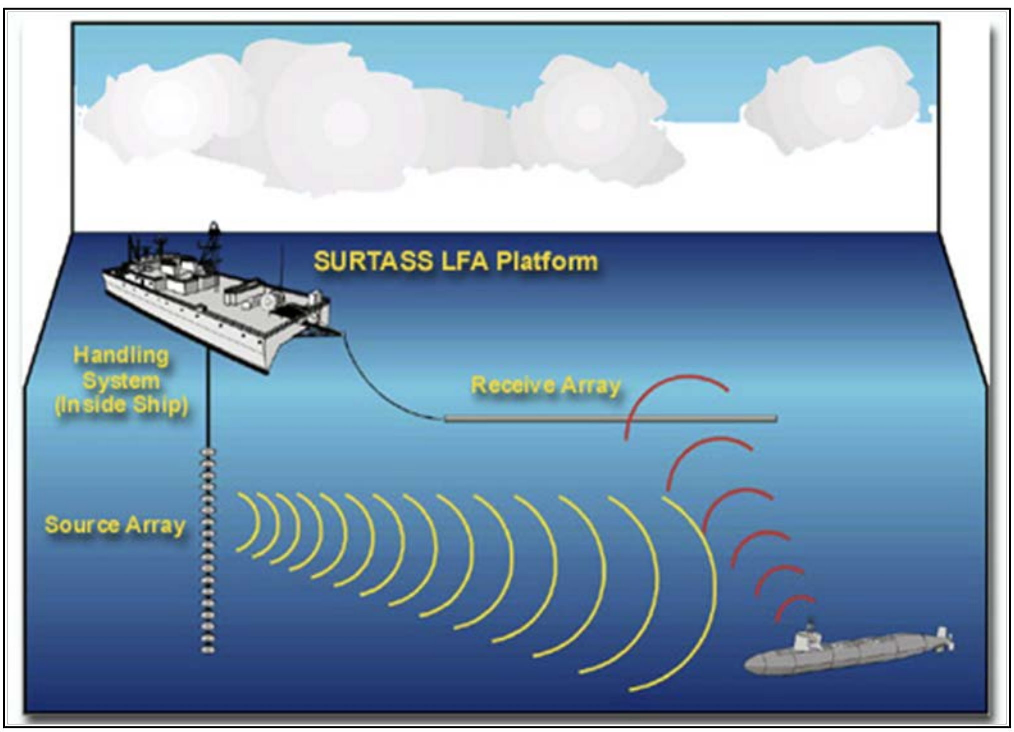

Figure 1-1. SURTASS LFA Sonar Systems Showing the Active (Source Array) and Passive (Receive Array) Components.

LFA systems were initially installed on two SURTASS ocean surveillance ships, RV *Cory Chouest*, which was retired in 2008, and USNS IMPECCABLE (Tactical-Auxiliary General Ocean Surveillance [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 system upgrade is known as Compact LFA, or CLFA. CLFA consists of smaller, lighter-weight source elements than the LFA system and is compact enough to be installed on the VICTORIOUS Class platforms (such as T-AGOS 19, 20, and 21). CLFA improvements include:

- Operational frequency, within the 100 to 500 Hz range, matched to shallow water environments with little loss of detection performance in deep water environments,
- Improved reliability and ease of deployment, and
- 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). 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 low frequency active sonar, or LFA sonar, will be used to refer to both the LFA and/or the CLFA sonar systems, unless otherwise specified.

1.5.1 Active Acoustic System

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

- The source is a vertical line array (VLA) of up to 18 source projectors suspended beneath the vessel. LFA's transmitted 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. A variety of signal types can be used, including continuous wave (CW) and frequency-modulated (FM) signals.
- 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 signal is not a constant tone, but rather a transmission of various 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 with an average length of 60 seconds. Within each wavetrain the duration of each continuous frequency sound transmission is no longer than 10 seconds.
- Average duty cycle (ratio of sound "on" time to total time) is less than 20 percent. The typical duty cycle, based on historical LFA operational parameters (2003 to 2016), is nominally 7.5 to 10 percent.
- The time between wavetrain transmissions is typically from 6 to 15 minutes (min).

LFA sonar complements SURTASS passive operations 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.

References to Underwater Sound Levels

- References to underwater sound pressure level (SPL) in this SEIS/SOEIS are values given in decibels (dBs), and are assumed to be standardized at 1 microPascal at 1 m (dB re 1 µPa at 1 m [rms]) for source level (SL) and dB re 1 µPa (rms) for received level (RL), unless otherwise stated (Urick, 1983; ANSI, 2006).
- In this SEIS/SOEIS, underwater sound exposure level (SEL) is a measure of energy, specifically the squared instantaneous pressure integrated over time; the appropriate units for SEL are dB re 1 μPa^2-sec (Urick, 1983; ANSI, 2006; Southall et al., 2007).
- The term "Single Ping Equivalent" (SPE) used herein is an intermediate calculation for input to the risk continuum used in the acoustic impact analysis for SURTASS LFA sonar. SPE accounts for the energy of all LFA sonar transmissions that a modeled animal ("animat") receives during a 24-hr period of a SURTASS LFA sonar 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 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, 2012a); and FSEIS/SOEIS (DoN, 2015).

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

Due to uncertainties in the world's political climate, a detailed account of future operating locations and conditions for SURTASS LFA sonar cannot be predicted. However, for analytical purposes, a nominal annual deployment schedule and operational concept were developed, based on actual LFA operations conducted since January 2003 and projected Fleet requirements. 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 operational scenario.

Annually, each vessel will be expected to spend approximately 54 days in transit and 240 days at sea conducting routine training, testing, and military operations (Table 2-1). Between missions, an estimated total of 71 days per year will be spent in port for upkeep and repair to maintain both the material condition of the vessel and its systems, and the morale of the crew. The actual number and length of the individual missions within the 240 days are difficult to predict, but the maximum number of actual transmission hours per vessel per year will not exceed 255 hr.

Table 2-1. Nominal Annual Deployment Schedule for SURTASS LFA Sonar Vessels.

Underway—Mission	*Days*	*Not Underway*	*Days*
Transit	54	In-Port Upkeep	40
Active Operations (255 hr transmissions per vessel based on 7.5 percent duty cycle[3])	240	Regular Overhaul	31
Total Underway	294	Total Not Underway	71
Total			365

2.2 Potential SURTASS LFA Sonar Operating Areas

As an integral part of the MMPA permitting process, as well as for the NEPA process, the Navy must anticipate, or predict, where they have to operate in the next five years. Naval forces are presently operating in several areas strategic to U.S. national and international interests, including areas in the Mediterranean Sea, Indian Ocean, Persian Gulf, and the Pacific Rim. National security needs may dictate

3 Note: 7.5 percent duty cycle is based on historical SURTASS LFA sonar operating parameters, which include downtime for:
- Corrective maintenance (equipment casualties or system failures)
- Preventive maintenance (database maintenance, daily archive, tow-point changes, and system upgrades)
- Ship re-positioning
- De-conflict interference with other naval sensor systems
- Emission control restrictions during naval operations and exercises.

that many of these operational areas will be close to ports and choke points, such as entrances to straits, channels, and canals. Also, many future naval conflicts are likely to occur within littoral or coastal areas. The Navy must balance national security needs with environmental requirements and impacts, while protecting both our freedom and the world's natural resources.

Due to the temporal limit (no more than five years) on NMFS' regulatory authority for regulations and LOAs under the MMPA process and the difficulty in predicting potential future operations for SURTASS LFA sonar, locations and conditions have only been projected for the future five-year period from 2017 through 2022. Potential operations for SURTASS LFA sonar vessels over these five years, based on current operational requirements, will most likely include areas located in the Pacific, Indian, and Atlantic oceans and Mediterranean Sea but will exclude the polar regions of the world (Figure 2-2). Polar waters are excluded from operational planning because of the inherent inclement weather conditions and the navigational and operational (equipment) danger that icebergs pose to SURTASS LFA sonar vessels. To reduce adverse impacts on the marine environment, the operation of SURTASS LFA sonar will include geographical restrictions to maintain RLs below 180 dB re 1 µPa rms SPL within 12 nmi (22 km) of any land and within the boundary of a designated OBIA during its respective effective period when significant biological activity occurs. Routine training and testing of SURTASS LFA sonar and participation in military operations will potentially take place within any of the operating areas.

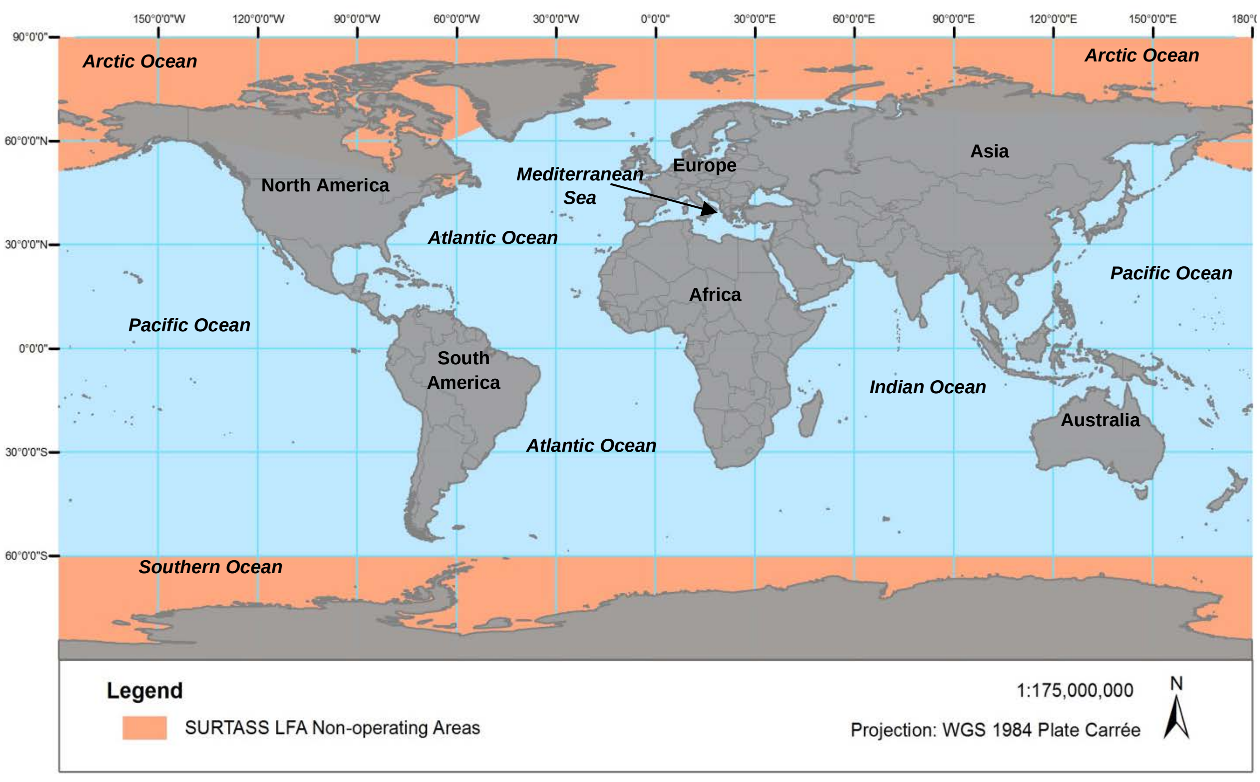

Figure 2-2. Potential Areas of Operation for SURTASS LFA Sonar.

2.2.1 Geographic Restrictions—Coastal Standoff Range

Based on the analyses presented in SURTASS LFA sonar NEPA documents (DoN, 2001, 2007, 2012, 2015, and 2016), geographic restrictions, including a "coastal standoff range," to the deployment of SURTASS LFA sonar have been developed to provide the lowest risk to marine mammals. The coastal standoff restriction states that during SURTASS LFA operations, the sound field produced by the sonar must be below 180 dB SPL within 12 nmi (22 km) of any coastline.

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

Under the MMPA, NMFS regulations under section 101(a)(5)(A) for incidental take authorization must set forth the permissible methods of taking and of other means of effecting the least practicable adverse impact on marine mammal species or stocks and their habitat, paying particular attention to rookeries, mating grounds, and areas of similar significance, and on the availability of the species or stock for subsistence uses. Practicability assessments for military readiness activities include a consideration of personnel safety, the practicality of implementation of any mitigation, and the impact on the effectiveness of the subject military readiness activity, and the requirements pertaining to the monitoring and reporting of such taking. These regulations must provide a determination that the operation of SURTASS LFA sonar would have no more than a negligible impact on the affected marine mammal stocks or habitats and would not have an unmitigable adverse impact on subsistence uses.

To meet MMPA least practicable adverse impact standard on species or stocks and their habitat, NMFS and the Navy developed mitigation measures to reduce the potential for adverse impacts. Given the unique operational characteristics of SURTASS LFA sonar, Navy and NMFS developed the concept of marine mammal OBIAs for SURTASS LFA sonar and created a systematic process for designating OBIAs in the SURTASS LFA Sonar FOEIS/EIS (DoN, 2001). Since the majority of areas of biological importance to protected marine mammal species and stocks are in coastal waters, the Navy established the policy of the coastal standoff range, in which waters within 12 nmi (22 km) of any land would not be ensonified with SURTASS LFA sonar at levels at or above 180 dB re 1 µPa (rms). 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 incidental takings 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.

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.

Geographic Criteria for OBIA Eligibility

The Navy will not operate SURTASS LFA sonar in certain geographic areas of the world (Figure 2). For a marine area to be eligible for consideration as an OBIA for marine mammals, the area must be located where SURTASS LFA sonar operates but cannot be located in:

- Coastal standoff zone or range—the area within 12 nmi (22 km) of the coastline of any land including islands or island systems.
- Polar regions—including the Arctic (portions of the Norwegian, Greenland, and Barents seas north of 72° N latitude, plus Baffin Bay, Hudson Bay, the Bering Sea, and the Gulf of St. Lawrence) and Antarctic (south of 60° S latitude).

Low-Frequency Hearing Sensitivity Criterion

For an area to be further considered as an OBIA for SURTASS LFA sonar, the area must be inhabited at least seasonally by marine mammal species whose best hearing sensitivity is in the LF range. Since SURTASS LFA sonar transmissions are well below the range of best hearing sensitivity for odontocetes and most pinnipeds based on measured hearing thresholds (Richardson et al., 1995; Nedwell et al., 2004; Southall et al., 2007; Au and Hastings, 2008; Houser et al., 2008; Kastelein et al., 2009; Mulsow and Reichmuth, 2010), OBIAs are designed to protect those marine mammal species, such as baleen whales, most likely to hear and be affected by LFA sonar transmissions.

Biological Criteria for OBIA Eligibility

In addition to meeting the geographical and LF hearing sensitivity 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 some combination of the following: available data, regional expertise, and/or habitat suitability models utilizing static and/or predictable dynamic oceanographic features and other factors that have been shown to be associated with high marine mammal densities.
- *Known Breeding/Calving or Foraging Ground or Migration Route:* An area representing a location of known biologically important activities including defined breeding or calving areas, foraging grounds, or migration routes, potential designation under this criterion is indicative that these areas are concentrated areas for at least one biologically important activity. "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.

Navy Practicability Criterion

- Once an area has been assessed to meet the geographical, LF frequency hearing sensitivity, and biological criteria and is eligible as a candidate OBIA for SURTASS LFA sonar, the Navy conducts a review of the potential OBIAs to assess personnel safety, practicality of implementation, and impacts on the effectiveness on military readiness activities, including routine training, testing, and military operations. 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.

2.2.2.2 Existing Marine Mammal OBIAs for SURTASS LFA Sonar

For the 2012 SEIS/SOEIS, the Navy designated 21 OBIAs for SURTASS LFA sonar, and NMFS designated one additional OBIA as part of the MMPA Final Rule for SURTASS LFA sonar, resulting in 22 designated marine mammal OBIAs for SURTASS LFA sonar (Table 2-2; Figure 2-3; DoN, 2012; NOAA, 2012a). Some of these areas, such as the Antarctic Convergence Zone, had been OBIAs previously designated 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.

2.2.2.3 Potential Marine Mammal OBIAs for SURTASS LFA Sonar

Since the 2012 SEIS/SOEIS and MMPA Final Rule for SURTASS LFA sonar, consideration and assessment of global marine areas as potential OBIAs has continued as part of the Adaptive Management process implemented by NMFS in the 2012 MMPA rulemaking (NOAA, 2012a). The Adaptive Management framework allows the Navy and NMFS to consider, on a case-by-case basis, newly available peer-reviewed scientific data, information, or survey data on marine areas that may be eligible for consideration as OBIAs. From 2012 to the present, the Navy and NMFS have continued to assess areas of the world's oceans for potential OBIAs for LFA sonar. 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 of the world's oceans for potential OBIAs for SURTASS LFA sonar, the Navy and NMFS conducted a comprehensive assessment of potential marine areas as part of the analysis and development of the Draft SEIS/SOEIS (DoN, 2016a). Based on an extensive review, eight new candidate OBIAs and the expansion of four existing OBIAs were

Table 2-2. Existing 22 Offshore Biologically Important Areas (OBIAs) for SURTASS LFA Sonar, the Relevant Low-Frequency Marine Mammal Species, and the Effective Seasonal Period for each OBIA.

OBIA Number	*Name of OBIA*	*Location/Water Body*	*Relevant Low-Frequency Marine Mammal Species*	*Effectiveness Seasonal Period*
1	Georges Bank	Northwest Atlantic Ocean	North Atlantic right whale	Year-round
2	Roseway Basin Right Whale Conservation Area	Northwest Atlantic Ocean	North Atlantic right whale	June through December, annually
3	Great South Channel, U.S. Gulf of Maine, and Stellwagen Bank NMS	Northwest Atlantic Ocean/ Gulf of Maine	North Atlantic right whale	January 1 to November 14, annually
4	Southeastern U.S. Right Whale Critical Habitat	Northwest Atlantic Ocean	North Atlantic right whale	November 15 to April 15, annually
5	North Pacific Right Whale Critical Habitat	Gulf of Alaska	North Pacific right whale	March through August, annually
6	Navidad Bank[4]	Caribbean Sea/Northwest Atlantic Ocean	Humpback whale	December through April, annually
7	Coastal Waters of Gabon, Congo and Equatorial Guinea	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 National Marine Sanctuaries	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	Piltun and Chayvo Offshore Feeding Grounds	Sea of Okhotsk	Western Pacific gray whale	June through November, annually
13	Coastal Waters off Madagascar	Western Indian Ocean	Humpback whale and Blue whale	July through September, annually for humpback whale breeding, November through December for migrating blue whales

4 OBIA name changed to indicate that Silver Bank is no longer encompassed within OBIA boundary but is instead encompassed in and afforded the protections of the coastal standoff range for SURTASS LFA sonar

Table 2-2. Existing 22 Offshore Biologically Important Areas (OBIAs) for SURTASS LFA Sonar, the Relevant Low-Frequency Marine Mammal Species, and the Effective Seasonal Period for each OBIA.

OBIA Number	*Name of OBIA*	*Location/Water Body*	*Relevant Low-Frequency Marine Mammal Species*	*Effectiveness Seasonal Period*
14	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 National Marine Sanctuary	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 Between 16°S and 21°S	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 National Marine Sanctuary and The Prairie, Barkley Canyon, and Nitnat Canyon	Northeastern Pacific Ocean	Humpback whale	Olympic National Marine Sanctuary: December, January, March, and May, annually; The Prairie, Barkley Canyon, and Nitnat Canyon: June through September, annually
22	Abrolhos Bank	Southwest Atlantic Ocean	Humpback whale	August through November, annually

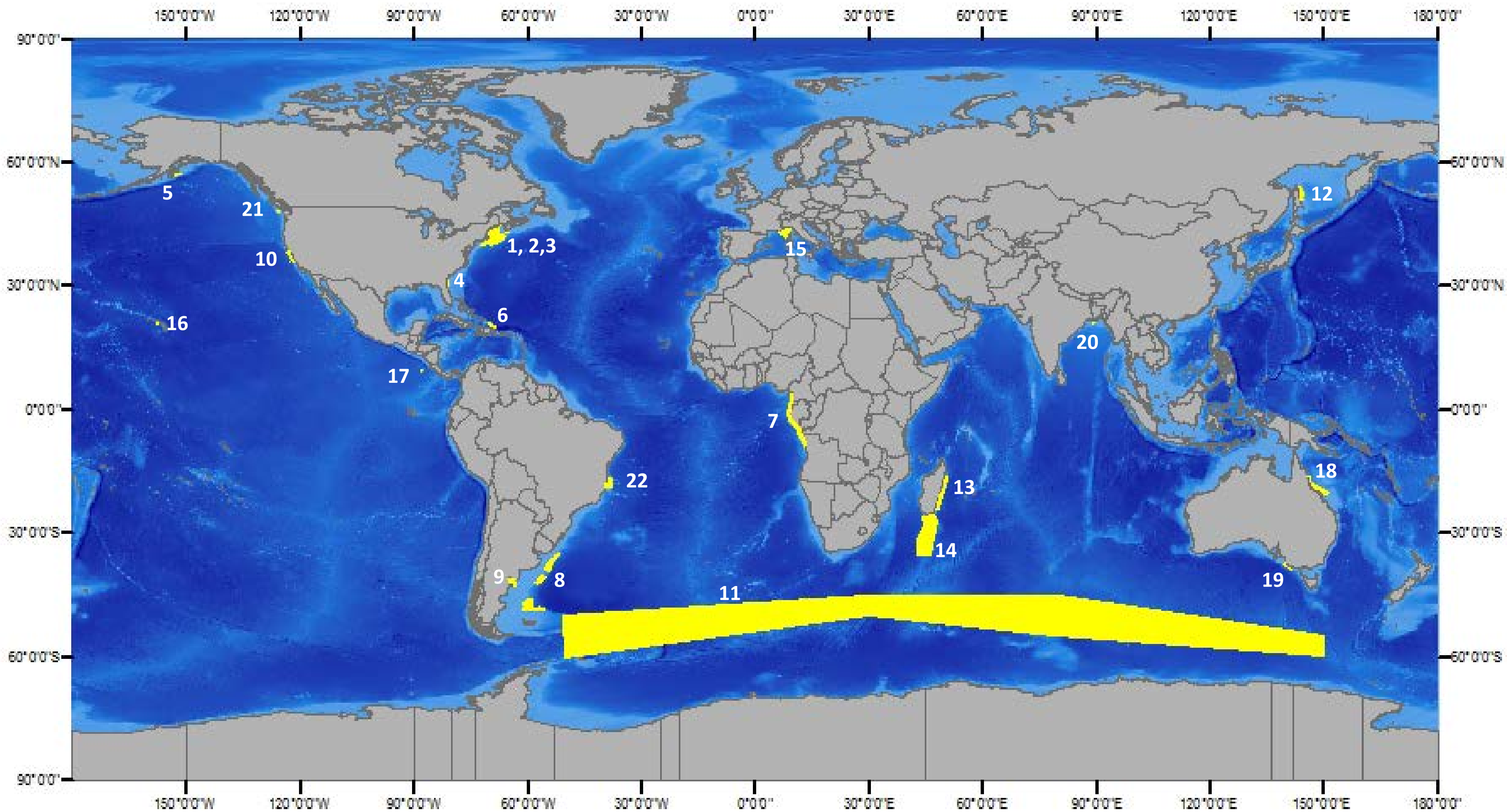

Figure 2-3. The Locations of the 22 Existing Marine Mammal Offshore Biologically Important Areas (OBIAs) for SURTASS LFA Sonar (The Names of OBIAs by Number Follows).

FIGURE 2-3: 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 Nitnat Canyon
22. Abrolhos Bank

evaluated by NMFS and Navy subject matter experts (SMEs) as part of the analysis and development of the Draft SEIS/SOEIS. During the review, it was suggested that Existing OBIA 5 (North Pacific Right Whale Critical Habitat) be expanded to include recent sightings of North Pacific right whales outside of defined critical habitat. After additional evaluation, Navy and NMFS agreed that sufficient data exist to meet the criteria for designation as a candidate OBIA. Existing OBIA 5 was renamed Gulf of Alaska to appropriately reflect the expansion beyond North Pacific Right Whale Critical Habitat and this expanded OBIA was added to the list of candidates (Table 2-3).

Therefore, after the SME review of preliminary candidate OBIAs, six new potential OBIAs and the expansion of five existing OBIAs were determined to meet the geographic, biological, and hearing criteria and were evaluated by the Navy for practicability. These eleven potential OBIAs were approved during the practicability review and are being proposed in the Draft SEIS/SOEIS and as part of this application (Table 2-3).

2.2.3 Potential Operating Areas—Modeled Sites

To achieve the purpose for which SURTASS LFA sonar was developed, the sonar must operate near potential ASW adversaries. However, the environmental impacts possibly resulting from the operation of the sonar in strategic areas must also be considered. Thus, a process that intertwines these mutual goals of minimizing the potential for environmental impacts while operating the sonar in relevant areas is necessary. The Navy and NMFS have developed a joint, scientifically-based process to select potential relevant operating areas for SURTASS LFA sonar while considering environmental impacts that has culminated in NMFS' issuance of annual LOAs. In addition, the Navy is required to develop an annual process, in consultation with NMFS, which identifies, through LOA application procedures, the locations that the Navy intends to operate within that year. Annual additional analyses (including acoustic modeling) are undertaken, if it is deemed necessary (e.g., updated marine mammal distribution or density data available for potential operating areas).

It is infeasible to analyze all worldwide potential operating or mission areas of SURTASS LFA sonar for all marine species and stocks for all seasons. Yet, designation of specific oceanic areas are necessary to conduct the acoustic impact modeling that will predict the potential impacts of SURTASS LFA sonar operations on marine species. For this purpose, twenty-six representative mission areas in the Pacific, Atlantic, and Indian oceans and the Mediterranean Sea were analyzed to represent the acoustic regimes and marine mammal species that may be encountered during LFA sonar operations (Table 2-4). Due to the large number of potential mission areas and seasons to be considered in the impact analysis, a seasonal sensitivity study was conducted to determine the optimal modeling season for each mission area. The modeling season was chosen based on an analysis of the sound velocity profiles and resulting sound propagation and transmission loss fields, with the season with the longest range acoustic propagation typically being selected. Seasons as applied herein are defined according to the following monthly breakdown:

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

For consistency, the seasonality for marine mammals in all mission areas is presented according to this monthly arrangement, even for mission areas located in the southern hemisphere. Winter in the southern hemisphere is austral summer, when for instance, most baleen whales would be expected to be foraging in Antarctic waters.

Table 2-3. Potential Offshore Biologically Important Areas (OBIAs) for SURTASS LFA Sonar.

Potential OBIA Number	*Potential OBIA Name*	*Water Body/Location*	*Relevant Low-Frequency Marine Mammal Species*	*Effective Seasonal Period*	*Notes*
1	Grand Manan North Atlantic Right Whale Critical Habitat	Bay of Fundy, Canada	North Atlantic right whale	June through December, annually	
2	Great South Channel, Gulf of Maine, and Stellwagen Bank National Marine Sanctuary (OBIA 3) Expansion	Northeast U.S. Atlantic waters	North Atlantic right whale	January 1 to November 14, annually	Expansion of northeastern U.S. critical habitat for the North Atlantic right whale
3	Southeastern U.S. Critical Habitat for the North Atlantic Right Whale (OBIA 4) Expansion	Southeast U.S. Atlantic waters	North Atlantic right whale	January 15 to April 15, annually	Expansion of OBIA 4—Southeastern U.S. critical habitat for the North Atlantic right whale
4	Eastern Gulf of Mexico	Eastern Gulf of Mexico	Bryde's whale	Year-round	
5	Central California	Southwest U.S. Pacific waters	Blue whale, Humpback whale	June through November, annually	Expansion of OBIA 10—Central California National Marine Sanctuaries
6	Southern Chile Coastal Waters	Gulf of Corcovado, Southeast Pacific Ocean; southwestern Chile	Blue whale	February to April, annually	
7	Offshore Sri Lanka	North-Central Indian Ocean	Blue whale	December through April, annually	
8	Great Barrier Reef	Coral Sea, Southwestern Pacific Ocean; northeastern Australia	Humpback whale	May through September, annually	Expansion of OBIA 18—Great Barrier Reef Between 16° and 21° S
9	Camden Sound/Kimberly Region	Southeast Indian Ocean; northwestern Australia	Humpback whale	June through September, annually	

Table 2-3. Potential Offshore Biologically Important Areas (OBIAs) for SURTASS LFA Sonar.

Potential OBIA Number	***Potential OBIA Name***	***Water Body/Location***	***Relevant Low-Frequency Marine Mammal Species***	***Effective Seasonal Period***	***Notes***
10	Perth Canyon	Southeast Indian Ocean; southwestern Australia	Pygmy blue whale/Blue whale	January through May, annually	
11	Gulf of Alaska	Gulf of Alaska	North Pacific right whale	March through August, annually	Expansion of OBIA 5—North Pacific Right Whale Critical Habitat

Table 2-4. Locations of the 26 Representative Mission Areas Modeled for SURTASS LFA Sonar Global Operations and the Season Modeled for Each Area.

Mission Area	*Mission Area Name*	*Season*	*Location of Modeling Area Center*	*Notes*
1	East of Japan	Summer	38°N, 148°E	Adjacent to Navy Japan Complex OPAREA
2	North Philippine Sea	Fall	29°N, 136°E	Adjacent to Navy Japan/Okinawa Complex OPAREA
3	West Philippine Sea	Fall	22°N/124°E	
4	Offshore Guam	Summer	11°N, 145°E	Navy Mariana Islands Testing and Training Area
5	Sea of Japan	Fall	39°N, 132°E	
6	East China Sea	Summer	26°N, 125°E	Navy Japan/Okinawa Complex OPAREA
7	South China Sea	Fall	14°N, 114°E	
8	Offshore Japan 25° to 40°N	Summer	30°N, 165°E	
9	Offshore Japan 10° to 25°N	Winter	15°N, 165°E	
10	Hawaii North	Summer	25°N, 158°W	Navy Hawaii-Southern California Training and Testing Area; Hawaii Operating Area
11	Hawaii South	Fall	19.5°N, 158.5°W	Navy Hawaii-Southern California Training and Testing Area; Hawaii Operating Area
12	Offshore Southern California	Spring	32°N, 120°W	Navy Hawaii-Southern California Training and Testing Area; Southern California Operating Area
13	Western North Atlantic (off Florida)	Winter	29°N, 76°W	Navy Atlantic Fleet Training and Testing Area; Jacksonville Operating Area
14	Eastern North Atlantic	Summer	56.4N, 10W	Northwest Approaches
15	Mediterranean Sea	Summer	39°N, 6°E	
16	Arabian Sea	Summer	14°N, 65°E	
17	Andaman Sea	Summer	7.5°N, 96°E	
18	Panama Canal	Winter	5°N, 81°W	Western Approach
19	Northeast Australia	Spring	23°S, 155°E	
20	Northwest of Australia	Winter	18°S, 110°E	
21	Northeast of Japan	Summer	52°N, 163°E	
22	Southern Gulf of Alaska	Summer	51°N, 150°W	

Table 2-4. Locations of the 26 Representative Mission Areas Modeled for SURTASS LFA Sonar Global Operations and the Season Modeled for Each Area.

Mission Area	*Mission Area Name*	*Season*	*Location of Modeling Area Center*	*Notes*
23	Southern Norwegian Basin (between Iceland and Norway)	Summer	65°N, 0°	
24	Western North Atlantic (off Virginia/Maryland)	Summer	36.9°N, 71.6°W	Navy Atlantic Fleet Training and Testing Area; Virginia Capes Operating Area
25	Labrador Sea	Winter	57°N, 50°W	
26	Sea of Okhotsk	Spring	51°N, 150°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 operations, two essential screening criteria were applied: the species or stocks had to occur at least seasonally in a potential operating area during the same time of year as the SURTASS LFA sonar would operate and had to possess sensory organs or tissues that allow the animals 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

One hundred four species or stocks of marine mammals capable of perceiving LF sounds potentially occur in the ocean areas in which SURTASS LFA sonar may operate. These species include 15 species of mysticete (baleen) whales, 60 species of odontocete (toothed) whales, and 29 species of pinnipeds (Table 3-1). Some of these species are only found seasonally in the potential SURTASS LFA sonar operating areas while others occur year-round. Due to the coastal standoff and OBIA geographic restrictions on the deployment of SURTASS LFA sonar, coastally-occurring and nearshore species such as sirenians, mustelids, river dolphins, and others are not included in the underwater acoustic risk assessment completed for SURTASS LFA sonar.

3.2 Marine Mammal Abundance and Density Estimates

For this LOA application and the Draft SEIS/SOEIS (DoN, 2016a), risk to the possible 104 marine mammal species or stocks associated with the transmission of LF sound was derived for 26 potential SURTASS LFA sonar operating areas (Table 2-4). Although the distribution of many marine mammal species is irregular and highly dependent upon geography, oceanography, and seasonality, density and abundance estimates for each marine mammal species 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 mission 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 more sophisticated sampling and analysis and are not always available for each species/stocks or distinct population segment (DPS) in all mission areas. In the rare cases where no abundance estimates were

Table 3-1. Marine Mammal Species and Stocks Potentially Occurring in SURTASS LFA Sonar Mission Areas and their Status Under the ESA and MMPA. Taxonomy Follows the Society for Marine Mammalogy (2016), with Species Shown in Alphabetical Order within each Family.

Family	***Marine Mammal Species***	***ESA Status***	***MMPA Status***
Pinnipeds			
Otariidae	Australian fur seal (*Arctocephalus pusillus doriferus)*		
	Australian sea lion (*Neophoca cinerea*)		
	California sea lion (*Zalophus californianus*)		
	Eastern (Loughlin's) Steller sea lion (*Eumetopias jubatus monteriensis)*		Depleted
	Galapagos fur seal (*Arctocephalus galapagoensis)*		
	Galapagos sea lion (*Zalophus wollebaeki)*		
	Guadalupe fur seal (*Arctocephalus philippii townsendi)*	Threatened	Depleted
	Juan Fernandez fur seal (*Arctocephalus philippii philippii)*		
	New Zealand fur seal (*Arctocephalus forsteri)*		
	New Zealand sea lion (*Phocarctos hookeri*)		
	Northern fur seal (*Callorhinus ursinus*)		Depleted—Pribilof Island/Eastern Pacific stock
	South African or Cape fur seal (*Arctocephalus pusillus pusillus)*		
	South American fur seal (*Arctocephalus australis*)		
	South American sea lion (*Otaria byronia*)		
	Subantarctic fur seal (*Arctocephalus tropicalis)*		
	Western Steller sea lion (*Eumetopias jubatus jubatus*)	Endangered—Western DPS/stock	Depleted
Phocidae	Atlantic gray seal *(Halichoerus grypus atlantica)*		
	Arctic ringed seal (*Pusa hispida hispida)*		Depleted
	Harbor seal (*Phoca vitulina*) (Pacific and Atlantic)		
	Harp seal (*Pagophilus groenlandicus*)		

Table 3-1. Marine Mammal Species and Stocks Potentially Occurring in SURTASS LFA Sonar Mission Areas and their Status Under the ESA and MMPA. Taxonomy Follows the Society for Marine Mammalogy (2016), with Species Shown in Alphabetical Order within each Family.

Family	*Marine Mammal Species*	*ESA Status*	*MMPA Status*
Phocidae (Continued)	Hawaiian monk seal (*Neomonachus schauinslandi*)	Endangered	Depleted
	Hooded seal (*Cystophora cristata*)		
	Mediterranean monk seal (*Monachus monachus)*	Endangered	Depleted
	Northern elephant seal (*Mirounga angustirostris)*		
	Okhotsk ringed seal (*Pusa hispida ochotensis)*	Threatened	Depleted
	Pacific bearded seal *(Erignathus barbatus nauticus)*	Threatened—Okhotsk DPS	Depleted
	Ribbon seal (*Histriophoca fasciata)*		
	Southern elephant seal (*Mirounga leonina)*		
	Spotted seal (*Phoca largha*)	Threatened—Southern DPS; Sea of Okhotsk DPS	Depleted—Southern DPS
Cetaceans—Mysticetes			
Balaenidae	Bowhead whale (*Balaena mysticetus*)	Endangered	Depleted
	North Atlantic right whale (*Eubalaena glacialis*)	Endangered	Depleted
	North Pacific right whale (*Eubalaena japonica*)	Endangered	Depleted
	Southern right whale (*Eubalaena australis*)	Endangered	Depleted
Neobalaenidae	Pygmy right whale (*Caperea marginata*)		
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)*	Endangered	Depleted
	Bryde's whale (*Balaenoptera edeni)*		
	Common minke whale (*Balaenoptera acutorostrata)*		
	Fin whale (*Balaenoptera physalus)*	Endangered	Depleted

Table 3-1. Marine Mammal Species and Stocks Potentially Occurring in SURTASS LFA Sonar Mission Areas and their Status Under the ESA and MMPA. Taxonomy Follows the Society for Marine Mammalogy (2016), with Species Shown in Alphabetical Order within each Family.

Family	*Marine Mammal Species*	*ESA Status*	*MMPA Status*
	Humpback whale (*Megaptera novaeangliae*)[5]	Endangered—Arabian Sea DPS, Cape Verde Islands/Northwest Africa DPS; Threatened—Central America DPS, Western North Pacific DPS	Depleted
	Omura's whale (*Balaenoptera omurai*)		
	Pygmy blue whale (*Balaenoptera musculus brevicauda)*		
	Sei whale (*Balaenoptera borealis*)	Endangered	Depleted
Cetaceans—Odontocetes			
Physeteridae	Sperm whale (*Physeter macrocephalus*)	Endangered	Depleted
Kogiidae	Dwarf sperm whale (*Kogia sima*)		
	Pygmy sperm whale (*Kogia breviceps)*		
Ziphiidae	Andrew's beaked whale (*Mesoplodon bowdoini*)		
	Arnoux's beaked whale (*Berardius arnuxii)*		
	Baird's beaked whale (*Berardius bairdii)*		
	Blainville's beaked whale (*Mesoplodon densirostris)*		
	Cuvier's beaked whale (*Ziphius cavirostris*)		
	Deraniyagala's beaked whale (*Mesoplodon hotaula)*		
	Gervais' beaked whale (*Mesoplodon europaeus)*		
	Ginkgo-toothed beaked whale (*Mesoplodon ginkgodens)*		
	Gray's beaked whale (*Mesoplodon grayi)*		

5 The humpback whale is currently listed as an endangered species throughout its range, but NMFS has proposed re-listing the humpback whale under the ESA into DPSs. Since the Navy assumes that NMFS will finalize the humpback re-listing before the Draft SEIS/SOEIS is finalized, the proposed DPS listings for the humpback whale are used in this Rulemaking Application. In addition to the ESA-listed DPSs, several additional DPSs are not listed under the ESA: West Indies DPS, Western North Pacific DPS, Hawaii DPS, Mexico DPS, Brazil DPS, Gabon/West Africa DPS, Southeast Africa/Madagascar DPS; West Australia DPS, East Australia DPS Oceania DPS, and Southeastern Pacific DPS.

Table 3-1. Marine Mammal Species and Stocks Potentially Occurring in SURTASS LFA Sonar Mission Areas and their Status Under the ESA and MMPA. Taxonomy Follows the Society for Marine Mammalogy (2016), with Species Shown in Alphabetical Order within each Family.

Family	*Marine Mammal Species*	*ESA Status*	*MMPA Status*
Ziphiidae (continued)	Hector's beaked whale (*Mesoplodon hectori)*		
	Hubb's beaked whale (*Mesoplodon carlhubbsi)*		
	Longman's beaked whale (*Indopacetus pacificus*)		
	Northern bottlenose whale (*Hyperodon ampullatus*)		
	Perrin's beaked whale (*Mesoplodon perrini)*		
	Pygmy beaked whale (*Mesoplodon peruvianus)*		
	Shepherd's beaked whale (*Tasmacetus sheperdi*)		
	Southern bottlenose whale (*Hyperodon planifrons)*		
	Sowerby's beaked whale (*Mesoplodon bidens)*		
	Spade-toothed beaked whale (*Mesoplodon traversii)*		
	Stejneger's beaked whale (*Mesoplodon stejnegeri)*		
	Strap-toothed beaked whale (*Mesoplodon layardii)*		
	True's beaked whale (*Mesoplodon mirus)*		
Monodontidae	Beluga (*Delphinapterus leucas*)	Endangered—Cook Inlet DPS	Depleted—Cook Inlet DPS
Delphinidae	Atlantic spotted dolphin (*Stenella frontalis)*		
	Atlantic white-sided dolphin (*Lagenorhynchus acutus)*		
	Chilean dolphin (*Cephalorhynchus eutropia)*		
	Clymene dolphin (*Stenella clymene)*		
	Commerson's dolphin (*Cephalorhynchus commersonii*)		
	Common bottlenose dolphin (*Tursiops truncatus*)		
	Dusky dolphin (*Lagenorhynchus obscurus)*		
	False killer whale (*Pseudorca crassidens*)	Endangered—Main Hawaiian Islands Insular DPS	Depleted—Main Hawaiian Islands Insular DPS
	Fraser's dolphin (*Lagenodelphis hosei*)		

Table 3-1. Marine Mammal Species and Stocks Potentially Occurring in SURTASS LFA Sonar Mission Areas and their Status Under the ESA and MMPA. Taxonomy Follows the Society for Marine Mammalogy (2016), with Species Shown in Alphabetical Order within each Family.

Family	*Marine Mammal Species*	*ESA Status*	*MMPA Status*
Delphinidae (continued)	Heaviside's dolphin (*Cephalorhynchus heavisidii)*		
	Hector's dolphin (*Cephalorhynchus hectori)*		
	Hourglass dolphin (*Lagenorhynchus cruciger)*		
	Indo-Pacific bottlenose dolphin (*Tursiops aduncus*)		
	Indo-Pacific common dolphin (*Delphinus delphis tropicalis)*		
	Killer whale (*Orcinus orca)*	Endangered—Southern Resident	Depleted—Southern Resident and AT1 Transient stocks
	Long-beaked common dolphin (*Delphinus delphis bairdii)*		
	Long-finned pilot whale (*Globicephala melas*)		
	Melon-headed whale (*Peponocephala electra*)		
	Northern right whale dolphin (*Lissodelphis borealis*)		
	Pacific white-sided dolphin (*Lagenorhynchus obliquidens)*		
	Pantropical spotted dolphin (*Stenella attenuata*)		
	Peale's dolphin (*Lagenorhynchus australis*)		
	Pygmy killer whale (*Feresa attenuata*)		
	Risso's dolphin (*Grampus griseus*)		
	Rough-toothed dolphin (*Steno bredanensis*)		
	Short-beaked common dolphin (*Delphinus delphis delphis*)		
	Short-finned pilot whale (*Globicephala macrorhynchus)*		
	Southern right whale dolphin (*Lissodelphis peronii)*		
	Spinner dolphin (*Stenella longirostris)*		
	Striped dolphin (*Stenella coeruleoalba)*		
	White-beaked dolphin (*Lagenorhynchus albirostris)*		
Phocoenidae	Dall's porpoise (*Phocoenoides dalli*) (*dalli and truei types)*		

Table 3-1. Marine Mammal Species and Stocks Potentially Occurring in SURTASS LFA Sonar Mission Areas and their Status Under the ESA and MMPA. Taxonomy Follows the Society for Marine Mammalogy (2016), with Species Shown in Alphabetical Order within each Family.

Family	*Marine Mammal Species*	*ESA Status*	*MMPA Status*
Phocoenidae (continued)	Harbor porpoise (*Phocoena phocoena*)		
	Spectacled porpoise (*Phocoena dioptrica)*		

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, North Pacific, and Atlantic waters (Carretta et al., 2016; Muto et al., 2016; and Waring et al., 2016), 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 26 mission areas were utilized first (e.g., Barlow, 2006). However, density estimates require more sophisticated sampling and analysis and were not always available for each species at all sites. When density estimates were not available from a survey in the operation area, density estimates from a region with similar oceanographic characteristics were extrapolated to the operation 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 mission areas/model sites were also derived from the Navy's Marine Species Density Database (DoN, 2016b). 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 mission 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 pilot whales and beaked whales, as well as the pygmy and dwarf sperm whales. Density estimates are available for these species groups rather than the individual species (Table 3-2).

Table 3-2. Marine Mammal Species, Stocks, Abundance Estimates, Density Estimates, as well as Associated References for 26 SURTASS Representative LFA Sonar Mission Areas and Season Modeled (References Found at End of Table).

Marine Mammal Species	*Stock[6] Name*	*Stock Abundance*	*Abundance References*	*Density Estimates (animals/km^2)*	*Density References*
Mission Area 1: Sea of Japan; Summer Season					
Blue whale	WNP	9,250	1, 2, 3	₽[7]	1, 10, 11, 12
Bryde's whale	WNP	20,501	4	0.0006	13
Common minke whale	WNP "O"	25,049	5	0.0022	5
Fin whale	WNP	9,250	1, 6	0.0002	1
Humpback whale	WNP stock and DPS[8]	1,328	7	0.00036	12, 14
North Pacific right whale	WNP	922	8	₽[7]	Ð[9]
Sei whale	NP	7,000	1, 9	0.0006	1, 15
Baird's beaked whale	WNP	8,000	16	0.0029	16
Common bottlenose dolphin	WNP	168,791	17	0.0171	17
Cuvier's beaked whale	WNP	90,725	10, 11	0.0031	10, 11
False killer whale	WNP	16,668	17	0.0036	17
Ginkgo-toothed beaked whale	NP	22,799	10, 11	0.0005	10, 11
Harbor porpoise	WNP	31,046	18, 19	0.0190	18
Hubbs' beaked whale	NP	22,799	10, 11	0.0005	10, 11
Killer whale	WNP	12,256	10, 11	0.0001	23
Kogia spp.	WNP	350,553	10, 11	0.0031	10, 11
Pacific white-sided dolphin	NP	931,000	20	0.0082	10, 11
Pantropical spotted dolphin	WNP	438,064	17	0.0259	17
Pygmy killer whale	WNP	30,214	10, 11	0.0021	10, 11

6 NP=North Pacific; EP=Eastern Pacific; WNP=Western North Pacific; CNP=Central North Pacific; ENP=Eastern North Pacific; WSP=Western South Pacific; ETP=Eastern Tropical Pacific; C/O/W=California/Oregon/Washington; AK=Alaska; ECS=East China Sea; SOJ=Sea of Japan; IA=Inshore Archipelago; NMI=Northern Mariana Islands; IND=Indian; NIND=Northern Indian; SIND=Southern Indian; WAU=Western Australia; AS=Arabian Sea; WNA=Western North Atlantic; ENA=Eastern North Atlantic; WM=Western Mediterranean; ANT=Antarctica

7 The ₽ symbol in the density column indicates that although the marine mammal stock or DPS occurs in that mission area, is not expected to occur during the season modeled. If a reference is provided, it was included because it describes the seasonal occurrence of the species.

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

9 The Ð symbol indicates that no density was available for this species; if a species is expected to occur during the modeled season, a density was necessary to compute takes, so the lowest value possible (0.00001) was assigned to the data-sparse species for the purpose of acoustic impact estimation.

Table 3-2. Marine Mammal Species, Stocks, Abundance Estimates, Density Estimates, as well as Associated References for 26 SURTASS Representative LFA Sonar Mission Areas and Season Modeled (References Found at End of Table).

Marine Mammal Species	*Stock[6] Name*	*Stock Abundance*	*Abundance References*	*Density Estimates (animals/km²)*	*Density References*
Risso's dolphin	WNP	83,289	17	0.0097	17
Rough-toothed dolphin	WNP	145,729	10, 11	0.0059	10, 11
Short-beaked common dolphin	WNP	3,286,163	10, 11	0.0761	10, 11
Short-finned pilot whale	WNP	53,608	17	0.0128	17
Sperm whale	NP	102,112	21, 22	0.00123	24
Spinner dolphin	WNP	1,015,059	10, 11	0.00083	25
Stejneger's beaked whale	WNP	8,000	16	0.0005	10, 11
Striped dolphin	WNP	570,038	17	0.0111	17
Mission Area 2: North Philippine Sea; Fall Season					
Blue whale	WNP	9,250	1, 2, 3	0.00001	1, 10, 11, 12
Bryde's whale	WNP	20,501	4	0.0006	13
Common minke whale	WNP "O"	25,049	5	0.0044	5
Fin whale	WNP	9,250	1, 6	₽[7]	1
Humpback whale	WNP stock and DPS	1,328	7	0.00089	12, 14
North Pacific right whale	WNP	922	8	₽[7]	Đ[9]
Omura's whale	WNP	1,800	26	0.00006	27
Blainville's beaked whale	WNP	8,032	10, 11	0.0005	10, 11
Common bottlenose dolphin	WNP	168,791	17	0.0146	17
Cuvier's beaked whale	WNP	90,725	10, 11	0.0054	10, 11
False killer whale	WNP	16,668	17	0.0029	17
Fraser's dolphin	WNP	220,789	10, 11	0.0069	29
Ginkgo-toothed beaked whale	NP	22,799	10, 11	0.0005	10, 11
Killer whale	WNP	12,256	10, 11	0.00009	23
Kogia spp.	WNP	350,553	10, 11	0.0031	10, 11
Long-beaked common dolphin	WNP	279,182	28	0.1158	28
Longman's beaked whale	WNP	4,571	29	0.00025	23
Melon-headed whale	WNP	36,770	10, 11	0.00428	24
Pacific white-sided dolphin	NP	931,000	20	₽[7]	10, 11

Table 3-2. Marine Mammal Species, Stocks, Abundance Estimates, Density Estimates, as well as Associated References for 26 SURTASS Representative LFA Sonar Mission Areas and Season Modeled (References Found at End of Table).

Marine Mammal Species	*Stock[6] Name*	*Stock Abundance*	*Abundance References*	*Density Estimates (animals/km²)*	*Density References*
Pantropical spotted dolphin	WNP	438,064	17	0.0137	17
Pygmy killer whale	WNP	30,214	10, 11	0.0021	10, 11
Risso's dolphin	WNP	83,289	17	0.0106	17
Rough-toothed dolphin	WNP	145,729	10, 11	0.0059	10, 11
Short-beaked common dolphin	WNP	3,286,163	10, 11	0.0562	10, 11
Short-finned pilot whale	WNP	53,608	17	0.0153	17
Sperm whale	NP	102,112	21, 22	0.00123	24
Spinner dolphin	WNP	1,015,059	10, 11	0.00083	25
Striped dolphin	WNP	570,038	17	0.0329	17
Mission Area 3: West Philippine Sea; Fall Season					
Blue whale	WNP	9,250	1, 2, 3	0.00001	1, 10, 11, 12
Bryde's whale	WNP	20,501	4	0.0006	13
Common minke whale	WNP "O"	25,049	5	0.0033	5
Fin whale	WNP	9,250	1, 6	₽[7]	1
Humpback whale	WNP stock and DPS	1,328	7	0.00089	12, 30
Omura's whale	WNP	1,800	26	0.00006	27
Blainville's beaked whale	WNP	8,032	10, 11	0.0005	10, 11
Common bottlenose dolphin	WNP	168,791	17	0.0146	17
Cuvier's beaked whale	WNP	90,725	10, 11	0.0003	10, 11
Deraniyagala's beaked whale	NP	22,799	10, 11, 31	0.0005	10, 11
False killer whale	WNP	16,668	17	0.0029	17
Fraser's dolphin	WNP	220,789	10, 11	0.0069	29
Ginkgo-toothed beaked whale	NP	22,799	10, 11	0.0005	10, 11
Killer whale	WNP	12,256	10, 11	0.00009	23
Kogia spp.	WNP	350,553	10, 11	0.0017	10, 11
Long-beaked common dolphin	WNP	279,182	10, 11	0.1158	28
Longman's beaked whale	WNP	4,571	29	0.00025	23
Melon-headed whale	WNP	36,770	10, 11	0.00428	24

Table 3-2. Marine Mammal Species, Stocks, Abundance Estimates, Density Estimates, as well as Associated References for 26 SURTASS Representative LFA Sonar Mission Areas and Season Modeled (References Found at End of Table).

Marine Mammal Species	*Stock[6] Name*	*Stock Abundance*	*Abundance References*	*Density Estimates (animals/km^2)*	*Density References*
Pantropical spotted dolphin	WNP	438,064	17	0.0137	17
Pygmy killer whale	WNP	30,214	10, 11	0.0021	10, 11
Risso's dolphin	WNP	83,289	17	0.0106	17
Rough-toothed dolphin	WNP	145,729	10, 11	0.0059	10, 11
Short-finned pilot whale	WNP	53,608	17	0.0076	17
Sperm whale	NP	102,112	21, 22	0.00123	24
Spinner dolphin	WNP	1,015,059	10, 11	0.00083	25
Striped dolphin	WNP	570,038	17	0.0164	17
Mission Area 4: Offshore Guam; Summer Season					
Blue whale	WNP	9,250	1, 2, 3	₽[7]	1, 10, 11, 12, 24
Bryde's whale	WNP	20,501	4	0.0004	24
Common minke whale	WNP "O"	25,049	5	₽[7]	10, 11
Fin whale	WNP	9,250	1, 6	₽[7]	10, 11
Humpback whale	WNP stock and DPS	1,328	7	₽[7]	12, 30
Omura's whale	WNP	1,800	26, 27	0.00004	27
Sei whale	NP	7,000	1, 9	₽[7]	24
Blainville's beaked whale	WNP	8,032	10, 11	0.001	29
Common bottlenose dolphin	WNP	168,791	17	0.00245	29
Cuvier's beaked whale	WNP	90,725	10, 11	0.00079	29
Deraniyagala's beaked whale	NP	22,799	10, 11, 32	0.00093	10, 11
Dwarf sperm whale	WNP	350,553	10, 11	0.00714	25
False killer whale	WNP	16,668	17	0.00111	24
Fraser's dolphin	CNP	16,992	29	0.0069	29
Ginkgo-toothed beaked whale	NP	22,799	10, 11	0.00093	10, 11
Killer whale	WNP	12,256	10, 11	0.00014	29
Longman's beaked whale	WNP	4,571	29	0.0019	29
Melon-headed whale	NMI	2,455	24	0.00428	24
Pantropical spotted dolphin	WNP	438,064	17	0.0226	24

Table 3-2. Marine Mammal Species, Stocks, Abundance Estimates, Density Estimates, as well as Associated References for 26 SURTASS Representative LFA Sonar Mission Areas and Season Modeled (References Found at End of Table).

Marine Mammal Species	*Stock[6] Name*	*Stock Abundance*	*Abundance References*	*Density Estimates (animals/km²)*	*Density References*
Pygmy killer whale	WNP	30,214	10, 11	0.00014	24
Pygmy sperm whale	WNP	350,553	10, 11	0.00291	25
Risso's dolphin	WNP	83,289	17	0.003	29
Rough-toothed dolphin	WNP	145,729	10, 11	0.0026	29
Short-finned pilot whale	WNP	53,608	17	0.0051	29
Sperm whale	NP	102,112	21, 22	0.00123	24
Spinner dolphin	WNP	1,015,059	10, 11	0.00083	25
Striped dolphin	WNP	570,038	17	0.00616	24
Mission Area 5: Sea of Japan; Fall Season					
Bryde's whale	WNP	20,501	4	0.0001	10, 11
Common minke whale	WNP "O"	25,049	5	0.0004	10, 11
Common minke whale	WNP "J"	893	33	0.00016	10, 11
Fin whale	WNP	9,250	1, 6	0.0009	10, 11
North Pacific right whale	WNP	922	8	~~P~~[7]	~~D~~[9]
Omura's whale	WNP	1,800	26, 27	0.00001	27
Western North Pacific gray whale	WNP stock/Western DPS	140	2	0.00001	~~D~~[9]
Baird's beaked whale	WNP	8,000	16	0.0003	16
Common bottlenose dolphin	IA	105,138	17, 34	0.00077	23
Cuvier's beaked whale	WNP	90,725	10, 11	0.0031	10, 11
Dall's porpoise	SOJ	173,638	35	0.0520	10, 11
False killer whale	IA	9,777	17, 34	0.0027	10, 11
Harbor porpoise	WNP	31,046	18, 19	0.0190	18
Killer whale	WNP	12,256	10, 11	0.00009	23
Kogia spp.	WNP	350,553	10, 11	0.0017	10, 11
Long-beaked common dolphin	WNP	279,182	28	0.1158	28
Pacific white-sided dolphin	NP	931,000	17, 20	~~P~~[7]	10, 11
Risso's dolphin	IA	83,289	17	0.0073	17
Rough-toothed dolphin	WNP	145,729	10, 11	0.0026	29

Table 3-2. Marine Mammal Species, Stocks, Abundance Estimates, Density Estimates, as well as Associated References for 26 SURTASS Representative LFA Sonar Mission Areas and Season Modeled (References Found at End of Table).

Marine Mammal Species	*Stock[6] Name*	*Stock Abundance*	*Abundance References*	*Density Estimates (animals/km²)*	*Density References*
Short-beaked common dolphin	WNP	3,286,163	10, 11	0.0860	10, 11
Short-finned pilot whale	WNP	53,608	17	0.0014	17
Sperm whale	NP	102,112	21, 22	0.00123	24
Spinner dolphin	WNP	1,015,059	10, 11	0.00083	25
Stejneger's beaked whale	WNP	8,000	16	0.0005	10, 11
Striped dolphin	IA	570,038	17	0.00584	23
Spotted seal	Southern stock and DPS	3,500	36, 37, 38	0.00001	Đ[9]
Mission Area 6: East China Sea; Summer Season					
Bryde's whale	ECS	137	39	0.0003	29
Common minke whale	WNP "O"	25,049	5	0.0044	5
Common minke whale	WNP "J"	893	33	0.0018	5
Fin whale	ECS	500	1, 6, 40	0.0002	1
North Pacific right whale	WNP	922	8	₽[7]	Đ[9]
Omura's whale	WNP	1,800	26, 27	0.00003	27
Western North Pacific gray whale	WNP stock/Western DPS	140	2	₽[7]	Đ[9]
Blainville's beaked whale	WNP	8,032	10, 11	0.0005	10, 11
Common bottlenose dolphin	IA	105,138	17, 34	0.00077	23
Cuvier's beaked whale	WNP	90,725	10, 11	0.0003	10, 11
False killer whale	IA	9,777	17, 34	0.00111	24
Fraser's dolphin	WNP	220,789	10, 11	0.00694	29
Ginkgo-toothed beaked whale	NP	22,799	10, 11	0.0005	10, 11
Killer whale	WNP	12,256	10, 11	0.00009	23
Kogia spp.	WNP	350,553	10, 11	0.0017	10, 11
Long-beaked common dolphin	WNP	279,182	28	0.1158	28
Longman's beaked whale	WNP	4,571	29	0.00025	23
Melon-headed whale	WNP	36,770	10, 11	0.00428	24
Pacific white-sided dolphin	NP	931,000	17, 20	₽[7]	10, 11
Pantropical spotted dolphin	WNP	219,032	17	0.01374	17

Table 3-2. Marine Mammal Species, Stocks, Abundance Estimates, Density Estimates, as well as Associated References for 26 SURTASS Representative LFA Sonar Mission Areas and Season Modeled (References Found at End of Table).

Marine Mammal Species	*Stock[6] Name*	*Stock Abundance*	*Abundance References*	*Density Estimates (animals/km²)*	*Density References*
Pygmy killer whale	WNP	30,214	10, 11	0.00014	24
Risso's dolphin	IA	83,289	17	0.0106	17
Rough-toothed dolphin	WNP	145,729	10, 11	0.0026	29
Short-beaked common dolphin	WNP	3,286,163	10, 11	0.0461	10, 11
Short-finned pilot whale	WNP	53,608	17	0.0016	24
Sperm whale	NP	102,112	21, 22	0.00123	24
Spinner dolphin	WNP	1,015,059	10, 11	0.00083	25
Striped dolphin	IA	570,038	17	0.00584	23
Spotted seal	Southern stock and DPS	1,000	41	0.00001	~~D~~[9]
Mission Area 7: South China Sea; Fall Season					
Bryde's whale	WNP	20,501	4	0.0006	13
Common minke whale	WNP "O"	25,049	5	0.0033	5
Common minke whale	WNP "J"	893	33	0.0018	5
Fin whale	WNP	9,250	1, 6	0.0002	1
Humpback whale	WNP stock and DPS	1,328	7	0.00036	12, 30
North Pacific right whale	WNP	922	8	~~P~~[7]	~~D~~[9]
Omura's whale	WNP	1,800	26, 27	0.00006	27
Western North Pacific gray whale	WNP stock/Western DPS	140	2	0.00001	~~D~~[9]
Blainville's beaked whale	WNP	8,032	10, 11	0.0005	10, 11
Common bottlenose dolphin	IA	105,138	34	0.00077	23
Cuvier's beaked whale	WNP	90,725	10, 11	0.0003	10, 11
Deraniyagala's beaked whale	NP	22,799	10, 11, 32	0.0005	10, 11
False killer whale	IA	9,777	34	0.00111	24
Fraser's dolphin	WNP	220,789	10, 11	0.00694	29
Ginkgo-toothed beaked whale	NP	22,799	10, 11	0.0005	10, 11
Killer whale	WNP	12,256	10, 11	0.00009	23
Kogia spp.	WNP	350,553	10, 11	0.0017	10, 11
Long-beaked common dolphin (Indo-	WNP	279,182	28	0.1158	28

Table 3-2. Marine Mammal Species, Stocks, Abundance Estimates, Density Estimates, as well as Associated References for 26 SURTASS Representative LFA Sonar Mission Areas and Season Modeled (References Found at End of Table).

Marine Mammal Species	*Stock[6] Name*	*Stock Abundance*	*Abundance References*	*Density Estimates (animals/km²)*	*Density References*
Pacific common dolphin)					
Longman's beaked whale	WNP	4,571	29	0.00025	23
Melon-headed whale	WNP	36,770	10, 11	0.00428	24
Pantropical spotted dolphin	WNP	219,032	17	0.01374	17
Pygmy killer whale	WNP	30,214	10, 11	0.00014	24
Risso's dolphin	IA	83,289	17	0.0106	17
Rough-toothed dolphin	WNP	145,729	10, 11	0.0026	29
Short-finned pilot whale	WNP	53,608	17	0.00159	24
Sperm whale	NP	102,112	21, 22	0.0012	24
Spinner dolphin	WNP	1,015,059	10, 11	0.00083	25
Striped dolphin	IA	570,038	17	0.00584	23
Mission Area 8: Offshore Japan 25° to 40°N; Summer Season					
Blue whale	WNP	9,250	1, 2, 3	₽[7]	1, 10,1 1, 12
Bryde's whale	WNP	20,501	4	0.00041	24
Common minke whale	WNP "O"	25,049	5	0.0003	5
Fin whale	WNP	9,250	1, 6	0.0001	1
Humpback whale	WNP stock and DPS	1,328	7	0.00036	12, 14
Sei whale	NP	7,000	1, 9	0.00029	24
Baird's beaked whale	WNP	8,000	16	0.0001	16
Blainville's beaked whale	WNP	8,032	23, 28	0.0007	23
Common bottlenose dolphin	WNP	168,791	17	0.00077	23
Cuvier's beaked whale	WNP	90,725	10, 11	0.00374	23
Dwarf sperm whale	WNP	350,553	10, 11, 28	0.0043	23
False killer whale	WNP	16,668	17	0.0036	17
Hubbs' beaked whale	NP	22,799	10, 11	0.0005	10, 11
Killer whale	WNP	12,256	10, 11	0.00009	23
Longman's beaked whale	WNP	4,571	29	0.0003	23
Melon-headed whale	WNP	36,770	10, 11	0.0027	23

Table 3-2. Marine Mammal Species, Stocks, Abundance Estimates, Density Estimates, as well as Associated References for 26 SURTASS Representative LFA Sonar Mission Areas and Season Modeled (References Found at End of Table).

Marine Mammal Species	*Stock[6] Name*	*Stock Abundance*	*Abundance References*	*Density Estimates (animals/km²)*	*Density References*
Mesoplodon spp.	WNP	22,799	10, 11, 28	0.0005	10, 11
Northern right whale dolphin	NP	68,000	20	₽[7]	Đ[9]
Pacific white-sided dolphin	NP	931,000	20	0.0048	10, 11
Pantropical spotted dolphin	WNP	438,064	17	0.0113	23
Pygmy killer whale	WNP	30,214	10, 11	0.0001	23
Pygmy sperm whale	WNP	350,553	10, 11, 28	0.0018	23
Risso's dolphin	WNP	83,289	17	0.0005	23
Rough-toothed dolphin	WNP	145,729	10, 11	0.0019	23
Short-beaked common dolphin	WNP	3,286,163	10, 11	0.0863	10, 11
Short-finned pilot whale	WNP	53,608	17	0.0021	23
Sperm whale	NP	102,112	21, 22	0.0022	23
Spinner dolphin	WNP	1,015,059	10, 11	0.0019	23
Stejneger's beaked whale	WNP	8,000	16	0.0005	10, 11
Striped dolphin	WNP	570,038	17	0.0058	23
Hawaiian monk seal	Hawaii	1,112	153	0.00001	Đ[9]
Northern fur seal	Western Pacific	503,609	42, 43	₽[7]	20
Mission Area 9: Offshore Japan 10° to 25°N; Winter Season					
Blue whale	WNP	9,250	1, 2, 3	0.00001	1, 10, 11, 12
Bryde's whale	WNP	20,501	4	0.0003	23
Fin whale	WNP	9,250	1, 6	0.00001	Đ[9]
Humpback whale	WNP stock and DPS	1,328	7	0.00036	12, 30
Omura's whale	WNP	1,800	26, 27	0.00003	27
Sei whale	NP	7,000	1, 6	0.0029	24
Blainville's beaked whale	WNP	8,032	23, 28	0.0007	23
Common bottlenose dolphin	WNP	168,791	17	0.00077	23
Cuvier's beaked whale	WNP	90,725	10, 11	0.00374	23
Deraniyagala's beaked whale	NP	22,799	10, 11, 32	0.00093	11,
Dwarf sperm whale	WNP	350,553	10, 11	0.0043	23

Table 3-2. Marine Mammal Species, Stocks, Abundance Estimates, Density Estimates, as well as Associated References for 26 SURTASS Representative LFA Sonar Mission Areas and Season Modeled (References Found at End of Table).

Marine Mammal Species	*Stock[6] Name*	*Stock Abundance*	*Abundance References*	*Density Estimates (animals/km^2)*	*Density References*
False killer whale	WNP	16,668	17	0.00057	23
Fraser's dolphin	CNP	16,992	29	0.00251	23
Ginkgo-toothed beaked whale	NP	22,799	10, 11	0.00093	11
Killer whale	WNP	12,256	10, 11	0.00009	23
Longman's beaked whale	WNP	4,571	29	0.00025	23
Melon-headed whale	WNP	36,770	10, 11	0.00267	23
Pantropical spotted dolphin	WNP	438,064	17	0.01132	23
Pygmy killer whale	WNP	30,214	10, 11	0.00006	23
Pygmy sperm whale	WNP	350,553	10, 11	0.00176	23
Risso's dolphin	WNP	83,289	17	0.00046	23
Rough-toothed dolphin	WNP	145,729	10, 11	0.00185	23
Short-finned pilot whale	WNP	53,608	17	0.00211	23
Sperm whale	NP	102,112	21, 22	0.00222	23
Spinner dolphin	WNP	1,015,059	10, 11	0.00187	23
Striped dolphin	WNP	570,038	17	0.00584	23
Mission Area 10: Hawaii North; Summer Season					
Blue whale	CNP	81	29, 44	₽[7]	29
Bryde's whale	Hawaii	798	29, 44	0.0003	29
Common minke whale	Hawaii	25,049	5	₽[7]	10, 11
Fin whale	Hawaii	58	29, 44	₽[7]	29
Humpback whale	Central Pacific stock/Hawaii DPS	10,103	14, 22	₽[7]	12, 30
Sei whale	Hawaii	178	29, 44	₽[7]	29
Blainville's beaked whale	Hawaii	2,338	29, 44	0.001	29
Common bottlenose dolphin	Hawaii Pelagic	5,950	29, 44	0.0025	29
	Kauai/Niihau	184	44, 45	0.0001	29, 46
	4-Islands	191	44, 45	0.0001	29, 46
	Oahu	743	44, 45	0.0003	29, 46

Table 3-2. Marine Mammal Species, Stocks, Abundance Estimates, Density Estimates, as well as Associated References for 26 SURTASS Representative LFA Sonar Mission Areas and Season Modeled (References Found at End of Table).

Marine Mammal Species	*Stock[6] Name*	*Stock Abundance*	*Abundance References*	*Density Estimates (animals/km^2)*	*Density References*
	Hawaii Island	128	44, 45	0.0001	29, 46
Cuvier's beaked whale	Hawaii	1,941	29, 44	0.0008	29
Dwarf sperm whale	Hawaii	17,519	25, 44	0.00714	25
False killer whale	Hawaii Pelagic	1,540	153, 154, 155	0.0006	47
	Main Hawaiian Islands Insular stock and DPS	151	2, 48	0.0012	48
	Northwestern Hawaiian Islands	617	153, 154, 155	0.0013	47
Fraser's dolphin	Hawaii	16,992	29, 44	0.0069	29
Killer whale	Hawaii	101	29, 44	0.00004	29
Longman's beaked whale	Hawaii	4,571	29, 44	0.0019	29
Melon-headed whale	Hawaiian Islands	5,794	44, 49, 50	0.0012	29
	Kohala Resident	447	44, 49, 50	0.03725	44
Pantropical spotted dolphin	Hawaiian Pelagic	15,917	29, 44	0.0067	29
	Hawaii Island	220	51	0.0067	29
	Oahu	220	51	0.0067	29
	4-Islands	220	51	0.0067	29
Pygmy killer whale	Hawaii	3,433	29, 44	0.0014	29
Pygmy sperm whale	Hawaii	7,138	25, 44	0.0029	25
Risso's dolphin	Hawaii	7,256	29, 44	0.003	29
Rough-toothed dolphin	Hawaii	6,288	29, 44	0.0026	29
Short-finned pilot whale	Hawaii	12,422	29, 44	0.0051	29
Sperm whale	Hawaii	3,354	29, 44	0.0014	29
Spinner dolphin	Hawaii Pelagic	3,351	25	0.0008	25
Spinner dolphin (continued)	Kauai/Niihau	601	44	0.007	25
	Hawaii Island	631	44	0.007	25
	Oahu/4-Islands	355	44	0.007	25
	Kure/Midway Atoll	260	44	0.007	25

Table 3-2. Marine Mammal Species, Stocks, Abundance Estimates, Density Estimates, as well as Associated References for 26 SURTASS Representative LFA Sonar Mission Areas and Season Modeled (References Found at End of Table).

Marine Mammal Species	*Stock[6] Name*	*Stock Abundance*	*Abundance References*	*Density Estimates (animals/km²)*	*Density References*
	Pearl and Hermes Reef	300	52, 53	0.007	25
Striped dolphin	Hawaii	20,650	29, 44	0.0084	29
Hawaiian monk seal	Hawaii	1,112	153	0.00001	Ð[9]
Mission Area 11: Hawaii South; Fall Season					
Blue whale	CNP	81	29, 44	0.00003	29
Bryde's whale	Hawaii	798	29, 44	0.0003	29
Common minke whale	Hawaii	25,049	5	0.0002	10, 11
Fin whale	Hawaii	58	29, 44	0.00002	29
Humpback whale	Central Pacific stock/Hawaii DPS	10,103	14, 22	0.00089	12, 30
Sei whale	Hawaii	178	29, 44	0.0001	29
Blainville's beaked whale	Hawaii	2,338	29, 44	0.001	29
Common bottlenose dolphin	Hawaii Pelagic	5,950	29, 44	0.00245	29
	Kauai/Niihau	184	44, 45	0.0001	29, 46
	4-Islands	191	44, 45	0.0001	29, 46
	Oahu	743	44, 45	0.0003	29, 46
	Hawaii Island	128	44, 45	0.0001	29, 46
Cuvier's beaked whale	Hawaii	1,941	29, 44	0.0008	29
Deraniyagala beaked whale	NP	22,799	10, 11, 32	0.00093	10, 11
Dwarf sperm whale	Hawaii	17,519	25, 44	0.00714	25
False killer whale	Hawaii Pelagic	1,540	153, 154, 155	0.0006	47
	Main Hawaiian Islands Insular stock and DPS	151	2, 48	0.0012	48
Fraser's dolphin	Hawaii	16,992	29, 44	0.0069	29
Killer whale	Hawaii	101	29, 44	0.00004	29
Longman's beaked whale	Hawaii	4,571	29, 44	0.0019	29
Melon-headed whale	Hawaiian Islands	5,794	44, 49, 50	0.0012	29
Melon-headed whale	Kohala Resident	447	44, 49, 50	0.03725	44

Table 3-2. Marine Mammal Species, Stocks, Abundance Estimates, Density Estimates, as well as Associated References for 26 SURTASS Representative LFA Sonar Mission Areas and Season Modeled (References Found at End of Table).

Marine Mammal Species	*Stock[6] Name*	*Stock Abundance*	*Abundance References*	*Density Estimates (animals/km^2)*	*Density References*
Pantropical spotted dolphin	Hawaiian Pelagic	15,917	29, 44	0.0067	29
	Hawaii Island	220	51	0.0067	29
	Oahu	220	51	0.0067	29
	4-Islands	220	51	0.0067	29
Pygmy killer whale	Hawaii	3,433	29, 44	0.0014	29
Pygmy sperm whale	Hawaii	7,138	25, 44	0.0029	25
Risso's dolphin	Hawaii	7,256	29, 44	0.003	29
Rough-toothed dolphin	Hawaii	6,288	29, 44	0.0026	29
Short-finned pilot whale	Hawaii	12,422	29, 44	0.0051	29
Sperm whale	Hawaii	3,354	29, 44	0.0014	29
Spinner dolphin	Hawaii Pelagic	3,351	25	0.0008	25
	Kauai/Niihau	601	44	0.007	25
	Hawaii Island	631	44	0.007	25
	Oahu/4-Islands	355	44	0.007	25
Striped dolphin	Hawaii	20,650	29, 44	0.0084	29
Hawaiian monk seal	Hawaii	1,112	153	0.00001	~~D~~[9]
Mission Area 12: Offshore Southern California; Spring Season					
Blue whale	ENP	1,647	2, 54	0.00011	55
Bryde's whale	ENP	13,000	56	0.00001	55
Common minke whale	C/O/W	478	2, 57, 58, 59	0.00026	55
Eastern North Pacific gray whale	ENP	20,990	2, 60	0.03090	55
Fin whale	C/O/W	3,051	2, 61	0.00022	55
Humpback whale	C/O/W stock/Mexico DPS	1,918	2	0.00121	55
Sei whale	ENP	126	2, 57, 58, 59	0.00009	55
Western North Pacific gray whale	WNP	140	2, 62	0.00001	~~D~~[9]
Baird's beaked whale	C/O/W	847	2, 58, 59	0.00046	55
Blainville's beaked whale	C/O/W	694	2, 63	0.00101	55
Common bottlenose dolphin	C/O/W Offshore	1,006	2, 58, 59	0.01230	55

Table 3-2. Marine Mammal Species, Stocks, Abundance Estimates, Density Estimates, as well as Associated References for 26 SURTASS Representative LFA Sonar Mission Areas and Season Modeled (References Found at End of Table).

Marine Mammal Species	*Stock[6] Name*	*Stock Abundance*	*Abundance References*	*Density Estimates (animals/km^2)*	*Density References*
Cuvier's beaked whale	C/O/W	6,590	2, 63	0.00358	55
Dall's porpoise	C/O/W	42,000	2	0.02184	55
Ginkgo-toothed beaked whale	C/O/W	694	2, 63	0.00020	55
Hubb's beaked whale	C/O/W	694	2, 63	0.00086	55
Killer whale	Eastern Pacific Offshore	240	2	0.00030	55
Long-beaked common dolphin	California	107,016	2, 28, 59	0.08591	55
Northern right whale dolphin	C/O/W	21,332	64	0.13352	55
Pacific white-sided dolphin	C/O/W (Northern and Southern)	26,930	2, 58, 59	0.21549	55
Perrin's beaked whale	C/O/W	694	2, 63	0.00088	55
Pygmy beaked whale	C/O/W	694	2, 63	0.00020	55
Pygmy sperm whale	C/O/W	579	2, 59	0.00108	55
Risso's dolphin	C/O/W	6,272	2, 58, 59	0.01000	55
Short-beaked common dolphin	C/O/W	411,211	2, 58, 59	0.95146	55
Short-finned pilot whale	C/O/W	760	2, 57, 58, 59	0.00031	55
Sperm whale	C/O/W	2,106	2, 65	0.00337	55
Stejneger's beaked whale	C/O/W	694	2, 63	0.00065	55
Striped dolphin	C/O/W	10,908	2, 58, 59	0.02592	55
California sea lion	U.S. (Pacific Temperate)	296,750	2	0.33596	55
Guadalupe fur seal	Mexico	7,408	66, 67	0.00387	55
Harbor seal	California	30,968	2	0.02033	55
Northern elephant seal	California Breeding	179,000	2, 68	0.03222	55
Northern fur seal	California	14,050	153	0.01775	55
Mission Area 13: Western North Atlantic (off Florida); Winter Season					
Common minke whale	Canadian East Coast	20,741	69	0.00230	70
Humpback whale	Gulf of Maine stock/West Indies DPS	12,312	7	0.00004	70
North Atlantic right whale	WNA	476	156	0.00002	70

Table 3-2. Marine Mammal Species, Stocks, Abundance Estimates, Density Estimates, as well as Associated References for 26 SURTASS Representative LFA Sonar Mission Areas and Season Modeled (References Found at End of Table).

Marine Mammal Species	*Stock[6] Name*	*Stock Abundance*	*Abundance References*	*Density Estimates (animals/km^2)*	*Density References*
Atlantic spotted dolphin	WNA	44,715	69	0.01143	70
Clymene dolphin	WNA	6,086	71	0.02522	70
Common bottlenose dolphin	Offshore WNA	77,532	69	0.04195	70
	Southern Migratory Coast	9,173	69	0.00155	70
	Northern Florida Coast	1,219	69	0.00155	70
Common bottlenose dolphin (cont'd)	Central Florida Coast	4,895	69	0.00155	70
Cuvier's beaked whale	WNA	6,532	69	0.00166	70
False killer whale	WNA	442	69	0.00008	70
Killer whale	WNA	67	72	0.00001	70
Kogia spp.	WNA	3,785	69	0.00094	70
Mesoplodon spp.	WNA	7,092	69	0.00180	70
Pantropical spotted dolphin	WNA	3,333	69	0.00608	70
Risso's dolphin	WNA	18,250	69	0.00411	70
Rough-toothed dolphin	WNA	271	69	0.00069	70
Short-beaked common dolphin	WNA	173,486	69	0.00125	70
Short-finned pilot whale	WNA	21,515	69	0.00616	70
Sperm whale	WNA	2,288	69	0.00083	70
Spinner dolphin	WNA	262	70	0.00040	70
Striped dolphin	WNA	54,807	69	0.00298	70
Mission Area 14: Eastern North Atlantic; Summer Season					
Blue whale	ENA	979	73	0.00002	73
Common minke whale	Northeast Atlantic	78,572	74	0.00329	73
Fin whale	ENA	9,019	75	0.00100	75
Humpback whale	Iceland stock/Cape Verdes and West Africa DPS	11,572	76	0.00009	77
Sei whale	Iceland-Denmark Strait	10,300	78, 79	0.00040	75
Atlantic white-sided dolphin	ENA	3,904	80	0.00001	77
Blainville's beaked whale	ENA	6,992	75	0.00700	75

Table 3-2. Marine Mammal Species, Stocks, Abundance Estimates, Density Estimates, as well as Associated References for 26 SURTASS Representative LFA Sonar Mission Areas and Season Modeled (References Found at End of Table).

Marine Mammal Species	*Stock[6] Name*	*Stock Abundance*	*Abundance References*	*Density Estimates (animals/km^2)*	*Density References*
Common bottlenose dolphin	ENA	35,780	75, 81	0.00200	75
Cuvier's beaked whale	ENA	6,992	75	0.00700	75
Gervais' beaked whale	ENA	6,992	75	0.00700	75
Harbor porpoise	ENA	375,358	81	0.07400	81
Killer whale	Northern Norway	731	82	0.00001	₫[9]
Kogia spp.	ENA	3,785	69	0.00079	70
Long-finned pilot whale	ENA	128,093	83	0.05400	75
Northern bottlenose whale	ENA	19,538	84	0.00260	85, 86
Risso's dolphin	ENA	18,250	69	0.00200	75, 81
Short-beaked common dolphin	ENA	172,930	75, 81	0.01000	75
Sowerby's beaked whale	ENA	6,992	75	0.00700	75
Sperm whale	ENA	7,785	85, 87, 88	0.00077	85, 88
Striped dolphin	ENA	67,414	75	0.00150	75
True's beaked whale	ENA	6,992	75	0.00700	75
White-beaked dolphin	ENA	16,536	81	0.01400	81
Gray seal	Northwest Europe	116,800	89	0.00040	90
Harbor seal	Northwest Europe	40,414	89	0.04000	90
Mission Area 15: Mediterranean Sea; Summer Season					
Fin whale	Mediterranean	3,583	91	0.00168	92
Common bottlenose dolphin	WM	1,676	93	0.00058	93
Cuvier's beaked whale	Alboran Sea	429	94	0.000108	94
Long-finned pilot whale	ENA	21,515	69	0.0027	95
Risso's dolphin	WM	5,320	96, 97	0.0011	95
Short-beaked common dolphin	WM	19,428	98	0.00144	98
Sperm whale	WM	396	99	0.00052	95
Striped dolphin	WM	117,880	100	0.0436	92
Mission Area 16: Arabian Sea; Summer Season					
Blue whale	NIND	3,432	101	0.00004	55

Table 3-2. Marine Mammal Species, Stocks, Abundance Estimates, Density Estimates, as well as Associated References for 26 SURTASS Representative LFA Sonar Mission Areas and Season Modeled (References Found at End of Table).

Marine Mammal Species	*Stock[6] Name*	*Stock Abundance*	*Abundance References*	*Density Estimates (animals/km²)*	*Density References*
Bryde's whale	NIND	9,176	56, 101	0.00040	55
Common minke whale	IND	257,500	101	0.00920	55
Fin whale	IND	1,716	101	0.00092	55
Humpback whale	AS stock and DPS	200	102, 103, 104	0.00005	55
Blainville's beaked whale	IND	16,867	56	0.00276	55
Common bottlenose dolphin	IND	785,585	56	0.05521	55
Cuvier's beaked whale	IND	27,272	56	0.00308	55
Deraniyagala beaked whale	IND	16,867	56	0.00278	55
Dwarf sperm whale	IND	10,541	56	0.00006	55
False killer whale	IND	144,188	56	0.00025	55
Fraser's dolphin	IND	151,554	56	0.00194	55
Ginkgo-toothed beaked whale	IND	16,867	56	0.00278	55
Indo-Pacific bottlenose dolphin	IND	7,850	56	0.00055	55
Killer whale	IND	12,593	56	0.00737	55
Long-beaked common dolphin (Indo-Pacific common dolphin)	IND	1,819,882	56	0.00013	55
Longman's beaked whale	IND	16,867	56	0.01193	55
Melon-headed whale	IND	64,600	56	0.00931	55
Pantropical spotted dolphin	IND	736,575	56	0.00922	55
Pygmy killer whale	IND	22,029	56	0.00141	55
Pygmy sperm whale	IND	10,541	56	0.00002	55
Risso's dolphin	IND	452,125	56	0.08952	55
Rough-toothed dolphin	IND	156,690	56	0.00075	55
Short-finned pilot whale	IND	268,751	56	0.03474	55
Sperm whale	NIND	24,446	56, 105	0.00877	55
Spinner dolphin	IND	634,108	56	0.00718	55
Striped dolphin	IND	674,578	56	0.15196	55
Mission Area 17: Andaman Sea; Summer Season					

Table 3-2. Marine Mammal Species, Stocks, Abundance Estimates, Density Estimates, as well as Associated References for 26 SURTASS Representative LFA Sonar Mission Areas and Season Modeled (References Found at End of Table).

Marine Mammal Species	*Stock[6] Name*	*Stock Abundance*	*Abundance References*	*Density Estimates (animals/km^2)*	*Density References*
Blue whale	NIND	3,432	101	0.00003	55
Bryde's whale	NIND	9,176	56, 101	0.00037	55
Common minke whale	IND	257,500	101	0.00968	55
Fin whale	IND	1,716	101	₽[7]	55
Omura's whale	IND	9,176	56, 101	0.00037	55
Blainville's beaked whale	IND	16,867	56	0.00094	55
Common bottlenose dolphin	IND	785,585	56	0.07261	55
Cuvier's beaked whale	IND	27,272	56	0.00480	55
Deraniyagala beaked whale	IND	16,867	56	0.00097	55
Dwarf sperm whale	IND	10,541	56	0.00006	55
False killer whale	IND	144,188	56	0.00024	55
Fraser's dolphin	IND	151,554	56	0.00180	55
Ginkgo-toothed beaked whale	IND	16,867	56	0.00097	55
Indo-Pacific bottlenose dolphin	IND	7,850	56	0.00073	55
Killer whale	IND	12,593	56	0.00730	55
Long-beaked common dolphin (Indo-Pacific common dolphin)	IND	1,819,882	56	0.00010	55
Longman's beaked whale	IND	16,867	56	0.00459	55
Melon-headed whale	IND	64,600	56	0.00878	55
Pantropical spotted dolphin	IND	736,575	56	0.00829	55
Pygmy killer whale	IND	22,029	56	0.00125	55
Pygmy sperm whale	IND	10,541	56	0.00001	55
Risso's dolphin	IND	452,125	56	0.09173	55
Rough-toothed dolphin	IND	156,690	56	0.00077	55
Short-finned pilot whale	IND	268,751	56	0.03543	55
Sperm whale	NIND	24,446	56, 101	0.00107	55
Spinner dolphin	IND	634,108	56	0.00701	55
Striped dolphin	IND	674,578	56	0.14123	55

Table 3-2. Marine Mammal Species, Stocks, Abundance Estimates, Density Estimates, as well as Associated References for 26 SURTASS Representative LFA Sonar Mission Areas and Season Modeled (References Found at End of Table).

Marine Mammal Species	*Stock[6] Name*	*Stock Abundance*	*Abundance References*	*Density Estimates (animals/km²)*	*Density References*
Mission Area 18: Panama Canal; Winter Season					
Blue whale	ENP	1,647	2, 54	0.00008	106
Bryde's whale	ETP	13,000	56, 107	0.0003	106, 108
Common minke whale	ETP	478	2	0.00031	11
Fin whale	ENP	832	11	~~P~~[7]	11
Humpback whale	Southeast Pacific stock/Central America DPS	6,000	109, 110	0.00001	~~D~~[9]
Blainville's beaked whale	ETP	25,300	56	0.00225	106
Common bottlenose dolphin	ETP	335,834	111	0.0375	106
Cuvier's beaked whale	ETP	20,000	56	0.00058	106
Deraniyagala's beaked whale	ETP	25,300	56	0.00225	106
False killer whale	ETP	39,800	56	0.0004	10, 11
Fraser's dolphin	ETP	289,300	56	0.001	10, 11
Ginkgo-toothed beaked whale	ETP	25,300	56	0.0016	10, 11
Killer whale	ETP	8,500	56	0.00015	112
Kogia spp.	ETP	11,200	56	0.014	10, 11, 106
Longman's beaked whale	ETP	25,300	56	0.00225	106
Melon-headed whale	ETP	45,400	56	0.00313	106
Mesoplodon spp.	ETP	25,300	56	0.00225	106
Pantropical spotted dolphin	Northeastern Pacific Offshore	640,000	113	0.0375	106
Pygmy killer whale	ETP	38,900	56	0.0014	10, 11
Pygmy beaked whale	ETP	25,300	56	0.00225	106
Risso's dolphin	ETP	110,457	111	0.01781	106
Rough-toothed dolphin	ETP	107,633	111	0.00488	106
Short-beaked common dolphin	ETP	3,127,203	111	0.005	106
Short-finned pilot whale	ETP	160,200	56	0.01813	106
Sperm whale	ETP	22,700	56	0.0047	10, 11

Table 3-2. Marine Mammal Species, Stocks, Abundance Estimates, Density Estimates, as well as Associated References for 26 SURTASS Representative LFA Sonar Mission Areas and Season Modeled (References Found at End of Table).

Marine Mammal Species	*Stock[6] Name*	*Stock Abundance*	*Abundance References*	*Density Estimates (animals/km^2)*	*Density References*
Spinner dolphin	Eastern	450,000	113	0.01875	106
Striped dolphin	ETP	964,362	111	0.08125	106
Mission Area 19: Northeast Australia; Spring Season					
Blue whale	WSP	9,250	1, 2, 3	0.00001	1, 10, 11, 12
Bryde's whale	WSP	20,501	4	0.0006	13
Common minke whale	WSP	25,049	5	0.0044	5
Fin whale	WSP	9,250	1,9	0.0002	1
Humpback whale	IWC Breeding Stock E1/East Australia DPS	14,500	114	0.00089	12, 14
Omura's whale	WSP	1,800	26	0.00006	27
Sei whale	WSP	7,000	1, 9	0.0006	1, 15
Blainville's beaked whale	WSP	8,032	10, 11	0.0005	10, 11
Common bottlenose dolphin	WSP	168,791	17	0.0146	17
Cuvier's beaked whale	WSP	90,725	10, 11	0.0054	10, 11
False killer whale	WSP	16,668	17	0.0029	17
Fraser's dolphin	WSP	220,789	10, 11	0.0069	29
Gingko-toothed beaked whale	WSP	22,799	10, 11	0.0005	10, 11
Killer whale	WSP	12,256	10, 11	0.00009	23
Kogia spp.	WSP	350,553	10, 11	0.0031	10, 11
Longman's beaked whale	WSP	4,571	29	0.00025	23
Melon-headed whale	WSP	36,770	10, 11	0.00428	24
Pantropical spotted dolphin	WSP	438,064	17	0.0137	17
Pilot whales	WSP	53,608	17	0.0153	17
Pygmy killer whale	WSP	30,214	10, 11	0.0021	10, 11
Risso's dolphin	WSP	83,289	17	0.0106	17
Rough-toothed dolphin	WSP	145,729	10, 11	0.0059	10, 11
Short-beaked common dolphin	WSP	3,286,163	10, 11	0.0562	10, 11
Sperm whale	WSP	102,112	21, 22	0.00123	24

Table 3-2. Marine Mammal Species, Stocks, Abundance Estimates, Density Estimates, as well as Associated References for 26 SURTASS Representative LFA Sonar Mission Areas and Season Modeled (References Found at End of Table).

Marine Mammal Species	*Stock[6] Name*	*Stock Abundance*	*Abundance References*	*Density Estimates (animals/km²)*	*Density References*
Spinner dolphin	WSP	1,015,059	10, 11	0.00083	25
Striped dolphin	WSP	570,038	17	0.0329	17
Mission Area 20: Northwest of Australia; Winter Season					
Antarctic minke whale	ANT	90,000	115	₽[7]	Đ[9]
Blue whale	SIND	1,657	116, 117	₽[7]	55
Bryde's whale	SIND	13,854	118	0.00032	55
Common minke whale	IND	257,500	101	₽[7]	55
Fin whale	SIND	38,185	119, 120	0.00001	55
Humpback whale	WAU stock and DPS	13,640	121	₽[7]	55
Omura's whale	IND	13,854	118	0.00032	55
Sei whale	IND	13,854	118	0.00001	55
Blainville's beaked whale	IND	16,867	56	0.00083	55
Common bottlenose dolphin	IND	3,000	122	0.03630	55
Cuvier's beaked whale	IND	76,500	123	0.00399	55
Dwarf sperm whale	IND	10,541	56	0.00004	55
False killer whale	IND	144,188	56	0.00020	55
Fraser's dolphin	IND	151,554	56	0.00145	55
Killer whale	IND	12,593	56	0.00585	55
Longman's beaked whale	IND	16,867	56	0.00393	55
Melon-headed whale	IND	64,600	56	0.00717	55
Pantropical spotted dolphin	IND	736,575	56	0.00727	55
Pygmy killer whale	IND	22,029	56	0.00100	55
Risso's dolphin	IND	452,125	56	0.07152	55
Rough-toothed dolphin	IND	156,690	56	0.00059	55
Short-finned pilot whale	IND	268,751	56	0.02698	55
Southern bottlenose whale	IND	599,300	124	0.00083	55
Spade-toothed beaked whale	IND	16,867	56	0.00083	55
Sperm whale	SIND	24,446	56	0.00096	55

Table 3-2. Marine Mammal Species, Stocks, Abundance Estimates, Density Estimates, as well as Associated References for 26 SURTASS Representative LFA Sonar Mission Areas and Season Modeled (References Found at End of Table).

Marine Mammal Species	*Stock[6] Name*	*Stock Abundance*	*Abundance References*	*Density Estimates (animals/km²)*	*Density References*
Spinner dolphin	IND	634,108	56	0.00561	55
Striped dolphin	IND	674,578	56	0.12018	55
Mission Area 21: Northeast of Japan; Summer Season					
Blue whale	WNP	9,250	1, 2, 3	₽[7]	1, 10, 11, 12
Common minke whale	WNP "O"	25,049	5	0.0022	5
Fin whale	WNP	9,250	1, 6	0.0002	1
Humpback whale	WNP stock and DPS	1,328	7	0.00050	55
North Pacific right whale	WNP	922	125	0.00001	Đ[9]
Sei whale	NP	7,000	1, 9	0.00029	24
Western North Pacific gray whale	WNP stock/Western DPS	140	2	0.00001	Đ[9]
Baird's beaked whale	WNP	8,000	16	0.0029	16
Cuvier's beaked whale	WNP	90,725	10, 11	0.0054	10, 11
Dall's porpoise	WNP	173,638	35	0.0650	10, 11
Killer whale	WNP	12,256	10, 11	0.0036	126
Pacific white-sided dolphin	NP	931,000	20	0.0048	10, 11
Short-beaked common dolphin	WNP	3,286,163	10, 11	0.0863	10, 11
Sperm whale	NP	102,112	21, 22	0.0022	23
Stejneger's beaked whale	WNP	8,000	16	0.0005	10, 11
Northern fur seal	Western Pacific	503,609	42, 43	0.01378	20
Ribbon seal	NP	61,100	22, 127	0.0452	128
Spotted seal	Alaska stock/Bering Sea DPS	460,268	22	0.2770	128
Steller sea lion	Western-Asian stock and Western DPS	62,218	157	0.00001	
Mission Area 22: Southern Gulf of Alaska; Summer Season					
Blue whale	ENP	1,647	2	0.00051	55
Common minke whale	AK	1,233	22	0.0006	55
Eastern North Pacific gray whale	ENP	20,990	2, 59	0.00019	55
Fin whale	AK/Northeast Pacific	1,368	22	0.00049	55

Table 3-2. Marine Mammal Species, Stocks, Abundance Estimates, Density Estimates, as well as Associated References for 26 SURTASS Representative LFA Sonar Mission Areas and Season Modeled (References Found at End of Table).

Marine Mammal Species	*Stock[6] Name*	*Stock Abundance*	*Abundance References*	*Density Estimates (animals/km^2)*	*Density References*
Humpback whale	WNP and CNP stocks/Hawaii, Mexico, and WNP DPSs	10,103	22	0.00050	55
North Pacific right whale	ENP	31	22	0.00003	55
Sei whale	ENP	126	2	0.00007	55
Baird's beaked whale	AK	847	2, 22	0.0004	55
Cuvier's beaked whale	AK	6,590	2, 22	0.00245	55
Dall's porpoise	AK	173,638	22	0.07214	55
Killer whale	ENP AK Resident	2,347	22, 157	0.005	55
	ENP Gulf of Alaska, Aleutian Islands, and Bering Sea Transient	587	22, 157	0.00021	55
Pacific white-sided dolphin	NP	26,880	20, 22	0.0208	55
Sperm whale	NP	102,112	21, 22	0.00127	55
Stejneger's beaked whale	AK	694	2, 22	0.00084	55
Northern elephant seal	California Breeding	179,000	2	0.00380	55
Northern fur seal	EP	648,534	22	0.03211	55
Ribbon seal	AK	184,000	157, 158	0.00001	55
Steller sea lion	Eastern U.S. stock/Eastern DPS	60,131	22	0.01085	55
	Western U.S. stock/Western DPS	49,497	157	0.01085	55
Mission Area 23: Southern Norwegian Basin; Summer Season					
Blue whale	ENA	979	73	0.00001	77
Common minke whale	Northeast Atlantic	78,572	74	0.03206	129, 130
Fin whale	North-West Norway	6,409	77	0.00157	77
Humpback whale	Iceland stock/Cape Verdes-West Africa and West Indies DPSs	11,572	76	0.00009	77

Table 3-2. Marine Mammal Species, Stocks, Abundance Estimates, Density Estimates, as well as Associated References for 26 SURTASS Representative LFA Sonar Mission Areas and Season Modeled (References Found at End of Table).

Marine Mammal Species	*Stock[6] Name*	*Stock Abundance*	*Abundance References*	*Density Estimates (animals/km^2)*	*Density References*
Sei whale	Iceland-Denmark Strait	10,300	79, 105, 131	0.00001	77
Atlantic white-sided dolphin	ENA	3,904	80	0.00001	77
Cuvier's beaked whale	ENA	6,992	75	0.011	75
Harbor porpoise	ENA	375,358	81	0.074	81
Killer whale	Northern Norway	731	82	0.00001	
Long-finned pilot whale	ENA	128,093	83	0.054	75
Northern bottlenose whale	ENA	19,538	84	0.0026	85, 86
Sowerby's beaked whale	ENA	6,992	75	0.011	75
Sperm whale	ENA	7,785	85, 87, 88	0.0049	87, 88
White-beaked dolphin	ENA	16,536	81	0.011	81
Hooded seal	West Ice	84,020	132	0.00811	133
Mission Area 24: Western North Atlantic (off Virginia/Maryland); Summer Season					
Common minke whale	Canadian East Coast	20,741	69	0.00013	70
Fin whale	WNA	1,618	69	0.00075	70
Humpback whale	Gulf of Maine stock/West Indies DPS	12,312	7	0.00006	70
North Atlantic right whale	WNA	476	156	0.00000	70
Atlantic spotted dolphin	WNA	44,715	69	0.09630	70
Clymene dolphin	WNA	6,086	71	0.01424	70
Common bottlenose dolphin	Offshore WNA	77,532	69	0.04241	70
	Northern Migratory Coastal	11,548	69	0.00236	70
	Southern Migratory Coastal	9,173	69	0.00236	70
Cuvier's beaked whale	WNA	6,532	69	0.00878	70
False killer whale	WNA	442	69	0.00008	70
Killer whale	WNA	67	72	0.00001	70
Kogia spp.	WNA	3,785	69	0.00079	70
Mesoplodon spp.	WNA	7,092	69	0.00954	70
Pantropical spotted dolphin	WNA	3,333	69	0.00515	70

Table 3-2. Marine Mammal Species, Stocks, Abundance Estimates, Density Estimates, as well as Associated References for 26 SURTASS Representative LFA Sonar Mission Areas and Season Modeled (References Found at End of Table).

Marine Mammal Species	*Stock[6] Name*	*Stock Abundance*	*Abundance References*	*Density Estimates (animals/km²)*	*Density References*
Risso's dolphin	WNA	18,250	69	0.02202	70
Rough-toothed dolphin	WNA	271	69	0.00060	70
Short-beaked common dolphin	WNA	173,486	69	0.07284	70
Short-finned pilot whale	WNA	21,515	69	0.02215	70
Sperm whale	WNA	2,288	69	0.01274	70
Spinner dolphin	WNA	262	70	0.00034	70
Striped dolphin	WNA	54,807	69	0.13345	70
Mission Area 25: Labrador Sea; Winter Season					
Blue whale	WNA	440	134	0.00002	73
Common minke whale	Canadian East Coast	20,741	69	0.00013	70
Fin whale	Canadian East Coast	1,352	135	0.00005	135
Humpback whale	Newfoundland-Labrador stock/West Indies DPS	12,312	7	0.00019	135
North Atlantic right whale	WNA	476	156	0.00000	70
Sei whale	Labrador Sea	965	136	0.00002	137
Atlantic white-sided dolphin	Labrador Sea	24,422	69, 135, 138	0.00200	135
Harbor porpoise	Newfoundland	3,326	69, 135, 138, 139	0.00160	135
Killer whale	WNA	67	72	0.00001	70
Long-finned pilot whale	Canadian East Coast	6,134	135, 138	0.00370	135
Northern bottlenose whale	Davis Strait	50	140, 141	0.00001	Ð[9]
Short-beaked common dolphin	WNA	173,486	69, 135, 138, 139	0.00100	135
Sowerby's beaked whale	WNA	50	69	0.00001	Ð[9]
Sperm whale	WNA	2,288	69	0.00127	70
White-beaked dolphin	Canadian East Coast	15,625	135, 138, 139	0.00077	135
Arctic ringed seal	Arctic	787,000	143	0.07300	140
Harp seal	WNA	7,411,000	142	0.07043	133
Hooded seal	WNA	592,100	137	0.00811	133
Mission Area 26: Sea of Okhotsk; Spring Season					

Table 3-2. Marine Mammal Species, Stocks, Abundance Estimates, Density Estimates, as well as Associated References for 26 SURTASS Representative LFA Sonar Mission Areas and Season Modeled (References Found at End of Table).

Marine Mammal Species	*Stock[6] Name*	*Stock Abundance*	*Abundance References*	*Density Estimates (animals/km²)*	*Density References*
Bowhead whale	Okhotsk Sea	247	144, 145	0.00001	145
Common minke whale	WNP "O"	25,049	5	0.01727	5
	WNP "J"	893	33	0.00062	5
Fin whale	WNP	9,250	1, 6	0.0002	1
Humpback whale	WNP stock and DPS	1,328	7	0.00089	12, 14
North Pacific right whale	WNP	922	125	₽[7]	Đ[9]
Western North Pacific gray whale	WNP stock/Western DPS	140	2	₽[7]	Đ[9]
Baird's beaked whale	WNP	8,000	16	0.0015	16
Beluga whale	Okhotsk Sea	12,226	146	0.0071	147
Cuvier's beaked whale	WNP	90,725	10, 11	0.0054	10, 11
Dall's porpoise	WNP dalli-type	111,402	148	0.18031	148
	WNP truei-type	101,173	148	0.16375	148
Harbor porpoise	WNP	31,046	18, 19	0.0190	18
Killer whale	Okhotsk-Kamchatka-Western Aleutians Transient	12,256	10, 11, 153	0.0036	126
Pacific white-sided dolphin	NP	931,000	20	0.0048	10, 11
Sperm whale	NP	102,112	21, 22	0.0022	23
Northern fur seal	Western Pacific	503,609	42, 43	0.08031	147
Okhotsk ringed seal	Okhotsk	676,000	150, 152	0.23881	147
Pacific bearded seal	Okhotsk stock and DPS	200,000	150	0.01174	147
Ribbon seal	Sea of Okhotsk	124,000	151	0.0904	128
Spotted seal	Sea of Okhotsk stock and DPS	180,000	150	0.2770	128
Steller sea lion	Western stock and DPS	82,516	22	0.02189	147

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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 areas of the world's oceans where SURTASS LFA sonar may be operated is 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. Even slow-moving cetaceans are capable of traveling nearly 200 km (108 nmi) within a 24-hour period. Some baleen whales, such as the humpback and North Atlantic right whales, 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. At nearly 8,690 nmi (16,093 km) round trip, the migratory movements of the humpback whale represent the longest migration of any mammal (Clapham, 2002). Despite this mobility, however, the distribution of marine mammals is not typically random and is not 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.

The following sections include information on the status, stocks, abundance, distribution, diving behavior, and hearing/vocalization for each of the marine mammal species potentially found in areas of the world's oceans where SURTASS LFA sonar may be operated.

4.1 Mysticetes

Mysticetes potentially affected by SURTASS LFA sonar include 15 species in five 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 low frequency sounds, although no direct measurements of auditory (hearing) thresholds have been made for the majority of 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 low-frequency sounds are not fully understood but likely are used for functions such as orientation, navigation, or detection of predators and prey. Several mysticete species, including the humpback, fin, bowhead, 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 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 Blue Whale (*Balaenoptera musculus*) and Pygmy Blue Whale (*Balaenoptera musculus brevicauda*)

The blue whale is currently listed as endangered under the ESA, depleted under the MMPA, protected under Convention on International Trade in Endangered Species (CITES), and as endangered (Antarctic), vulnerable (North Atlantic), and lower risk/conservation dependent (North Pacific) by the IUCN. The pygmy blue whale (*Balaenoptera musculus brevicauda*) is a subspecies of blue whale that occurs in the Southern Hemisphere, especially in the Indian Ocean. The global population of blue whales is estimated between 10,000 to 25,000 individuals (Jefferson et al., 2015), while 81 blue whales are estimated to occur in the Central North Pacific; 1,647 in the Eastern North Pacific (Carretta et al., 2015); 9,250 whales are estimated in the Western North Pacific (Stafford et al., 2001; Tillman, 1977); 9,250 blue whales are estimated to occur in the Western South Pacific (Stafford et al., 2001; Tillman, 1977); and 1,700 blue whales are estimated for the Southern Ocean (Branch et al., 2007). Although there is no best population estimate for the North Atlantic Ocean, 440 blue whales are estimated in the Western North Atlantic stock (Waring et al., 2014), while 979 blue whales are estimated for the Eastern North Atlantic (Pike et al., 2009). In the Northern Indian Ocean, 3,432 blue whales have been estimated to occur (IWC, 2016), with 424 blue whales estimated for the Madagascar Plateau of the western Indian Ocean region in the austral summer (Best et al., 2003), and 1,657 blue whales in the Southern Indian Ocean (Jenner et al., 2008; McCauley and Jenner, 2010).

Blue whales are distributed in subpolar to tropical continental shelf and deeper waters of all oceans and migrate between higher latitudes in summer and lower latitudes in winter (Jefferson et al., 2015; Sears and Perrin, 2009). Blue whales in the North Atlantic migrate as far north as Jan Mayen Island and Spitsbergen, Norway, in the summer but during the winter, they may migrate as far south as Florida or Bermuda (Jefferson et al., 2015). In the North Pacific, blue whales can be found as far north as the Gulf of Alaska but are mostly observed in California waters in the summer and Mexican and Central American waters in the winter (Jefferson et al., 2015; Sears and Perrin, 2009). Blue whales appear to be concentrated near Cape Mendocino, the Gulf of the Farallones and the Channel Islands (Irvine et al., 2014). Blue whales are also commonly found in the Southern Ocean (Jefferson et al., 2015). Blue whales in the southeast Pacific Ocean appear to migrate between low latitude Eastern Tropical Pacific and high latitude regions off Chile (Buchan et al., 2015). At least some blue whales near Sri Lanka in the Indian Ocean remain at low-latitudes throughout the year, presumably because oceanographic upwelling supports sufficient productivity (de Vos et al., 2014). Pygmy blue whales off the west coast of Australia moved between ~42°S to the Molucca Sea, near the equator (Double et al., 2014). Blue whales have recently been spotted off Angola, part of the population that migrates between Gabon and South Africa

(Figueiredo and Weir, 2014). They have also been recorded and visually identified off New Zealand (Miller et al., 2014).

The swimming and diving behavior of blue whales has been relatively well characterized. The average surface speed for a blue whale is 2.4 kt (4.5 kph) but can reach a maximum speed of 18.9 kt (45 kph) (Mate et al., 1999; Sears and Perrin, 2009). General dive times range from 4 to 15 min with average depths of 460 ft (140 m) (Croll et al., 2001b; Sears and Perrin, 2009). The longest dive recorded was 36 min (Sears and Perrin, 2009). The mean surface interval has been measured at 145 seconds (de Vos et al., 2013).

There is no direct measurement of the hearing sensitivity of blue whales (Ketten, 2000; Nummela, 2009). In one of the few studies to date, no change in blue whale vocalization pattern or movements relative to an LFA sound source was observed for RLs of 70 to 85 dB (Aburto et al., 1997). Croll et al. (2001) studied the impacts of anthropogenic low-frequency noise on the foraging ecology of blue and fin whales off San Nicolas Island, California and observed no responses or change in foraging behavior that could be attributed to the low-frequency sounds. Control Exposure Experiments, presenting simulated mid-frequency (MF) sonar signals, did produce brief changes in deep-feeding and non-feeding whales, while surface-feeding whales were not affected (Goldbogen et al., 2013). Their vocalization rate appears to decrease in response of MF sonar, and increase in the presence of vessel noise (Melcón et al., 2012).

Blue whales produce a variety of LF vocalizations ranging from 10 to 200 Hz (Clark and Fristrup, 1997; Edds, 1982; Rivers, 1997; Stafford et al., 1998; Stafford et al., 1999a, 1999b, 2001; Thompson and Friedl, 1982) Alling and Payne, 1990). These low frequency calls may be used as communicative signals (McDonald et al., 1995). Short sequences of rapid FM calls below 90 Hz are associated with animals in social groups (Mellinger and Clark, 2003; Moore et al., 1999). The most typical blue whale vocalizations are infrasonic sounds in the 15 or 17 to 20 Hz range (Sears and Perrin, 2009). The seasonality and structure of the vocalizations suggest that these are male song displays for attracting females and/or competing with other males. At SLs ranging 180 to 190 dB re 1 µPa @ 1 m, blue whale vocalizations are among the loudest made by any animal (Aroyan et al., 2000; Cummings and Thompson, 1971). However, calls produced during foraging have been measured at lower source levels, ranging from 158 to 169 dB re 1µPa @ 1 m (Akamatsu et al., 2014).

Blue whales produce long, patterned hierarchically organized sequences of vocalizations 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. 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).

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).

Non-song calls are now being described. Pygmy blue whale calls off Australia were produced in at least five types composed of amplitude and frequency modulated components with frequencies ranging from 20 to 750 Hz and durations between 0.9 and 4.4 seconds (Recalde-Salas et al., 2014). Calls produced by foraging blue whales off Iceland were frequency modulated downsweeps with a frequency range of 105 to 48 Hz and durations of 1-2 seconds (Akamatsu et al., 2014).

4.1.2 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. The global population estimate is roughly 140,000 whales (Jefferson et al., 2015). In the U.S. western North Atlantic, 1,618 fin whales have been estimated (Waring et al., 2015); 1,352 fin whales are estimated for the Canadian East Coast stock (Lawson and Gosselin, 2009); while the population estimated for the central and eastern North Atlantic is 30,000 individuals (IWC, 2009); with 9,019 whales of the number estimated for the Eastern North Atlantic (Hammond et al., 2013); and further north, the North-West Norway population is estimated to include 6,409 fin whales (Øien, 2009). The IWC (2009) estimates that 3,200 fin whales exist in West Greenland. Forcada et al. (1996) estimated that 3,583 fin whales occur in the Mediterranean Sea. The California/Oregon/ Washington population includes an estimated 3,051 whales; in the Eastern North Pacific, fin whales are estimated to number 832 individuals (Ferguson and Barlow, 2003); the population in Hawai'i is estimated as 58 fin whales (Carretta et al., 2014); and the Western North and Western South Pacific stocks have been estimated as 9,250 individuals (Mizroch et al., 2009; Mizroch et al., 2015; Tillman, 1977). The Indian Ocean population of fin whales has been estimated to include 1,716 individuals (IWC, 2016), while the Southern Indian Ocean stock off western Australia is estimated as 38,185 fin whales (Branch and Butterworth, 2001; Mori and Butterworth, 2006).

Fin whales are widely distributed in all oceans of the world. They are primarily found in temperate and cool waters. Fin whales migrate seasonally between higher latitudes for foraging and lower latitudes for mating and calving (Jefferson et al., 2015). Specific breeding areas are unknown and mating is assumed to occur in pelagic waters, presumably some time during the winter when the whales are in mid-latitudes. Foraging grounds tend to be near coastal upwelling areas and data indicate that some whales remain year round at high latitudes (Clark et al., 1998; Thompson et al., 1992).

Swimming speeds average between 5 to 8 kt (9.2 and 14.8 kph) (Aguilar, 2009). 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). Maximum dive depths have been recorded deeper than 1,181 ft (360 m) (Charif et al., 2002). Fin whales forage at dive depths between 328 to 656 ft (100 and 200 m), with foraging dives lasting from 3 to 10 min (Aguilar, 2009).

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", which is a low frequency (18 to 35 Hz) loud and long (0.5 to 1.5 sec) patterned sequence signal (Clark et al., 2002; Patterson and Hamilton, 1964; Watkins et al., 1987a). The pulse patterns of the 20-Hz signal vary geographically and with seasons (Clark et al., 2002; Croll et al., 2002; Morano et al., 2012). Regional differences in vocalization production and structure have been found between the Gulf of California and several Atlantic and Pacific Ocean regions. 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 region, 20-Hz signals are produced regularly throughout the year. Atlantic fin whales also produce higher frequency downsweeps ranging from 100 to 30 Hz (Frankel, 2009). 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). Croll et al. (2002) verified the earlier conclusion of Watkins et al. (1987a) that the 20-Hz vocalizations are only produced by male fin whales and likely are male breeding displays. Fin whales also produce 40 Hz downsweeps (Širović et al., 2012; Watkins, 1981).

Croll et al. (2001b) studied the impacts of anthropogenic low-frequency sound with RLs greater than 120 dB on the foraging ecology and vocalizations of blue and fin whales off San Nicolas Island, California. No obvious responses of either whale species was detected that could be attributable to the anthropogenic low-frequency sounds produced by SURTASS LFA sonar (Croll et al. 2001b). A comparison of fin whales in the Mediterranean Sea and the Northeast Atlantic Ocean found that fin whale calls shrank in duration and decreased in frequency in response to vessel and airgun noise. Additionally the whales appeared to move away from the airgun array source (Castellote et al., 2012).

4.1.3 Sei Whale (*Balaenoptera borealis*)

The sei whale is currently listed as endangered under the ESA, depleted under the MMPA, protected under CITES, and as endangered by the IUCN. The global population for the sei whale is estimated to be at least 80,000 whales (Jefferson et al., 2015). The population estimate in Nova Scotian waters is 357 whales (Waring et al., 2014), while the population of the central North Atlantic is estimated as 10,000 whales (Horwood, 2009). Sei whales in the Iceland-Denmark Strait stock number 10, 300 individuals (Cattanach et al., 1993; Donovan, 1991), and the population of the Labrador Sea stock includes 965 sei whales (Mitchell and Chapman, 1977). In the eastern North Pacific, an estimated 126 whales occur and 178 sei whales are estimated to occur in Hawaiian waters (Bradford et al., 2013; Carretta et al., 2014). The North Pacific and Western South Pacific stocks of sei whales are estimated to include 7,000 whales (Mizroch et al., 2009; Mizroch et al., 2015; Tillman, 1977). The Indian Ocean stock of sei whales is estimated as 13,854 whales (IWC, 1981).

Sei whales are primarily found in temperate zones of the world's oceans. Like other members of the family Balaenopteridae, sei whales are assumed to migrate to subpolar higher latitudes where they feed during the late spring through early fall, followed by movements to lower latitudes where they breed and calve during the fall through winter (Jefferson et al., 2015). In the North Atlantic, sei whales are located off Nova Scotia and Labrador during the summer and as far south as Florida during the winter (Leatherwood and Reeves, 1983). A migratory corridor between the Labrador Sea and the Azores has been established (Prieto et al., 2014). These data confirm cross-basin migratory paths in sei whales. In the North Pacific, they range from the Gulf of Alaska to California in the east and from Japan to the Bering Sea in the west. Specific breeding grounds are not known for this species, although the waters off NW Africa have been suggested for the North Atlantic sei whales (Prieto et al., 2014).

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 13.5 kt (25 kph) (Jefferson et al., 2008). Prieto et al. (2014) reported mean speeds during migration of 3.3 to 4 kt (6.2 to 7.4 kph) "off migration". Dive times range from 0.75 to 15 min, with a mean duration of 1.5 min (Schilling et al., 1992). Sei whales make shallow foraging dives of 65 to 100 ft (20 to 30 m), followed by a deep dive up to 15 min in duration (Gambell, 1985).

There is no direct measurement of the hearing sensitivity of sei whales (Ketten, 2000; Thewissen, 2002). Sei whale vocalizations are the least studied of all the rorquals. Rankin and Barlow (2007) recorded sei whale vocalizations in Hawai'i 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 frequency of 433 Hz. A series of sei whales FM calls have been recorded south of New Zealand (Calderan et al., 2014). These calls have a frequency range from 87 to 34 Hz and a duration of 0.4 to 1.7 sec.

4.1.4 Bryde's Whale (*Balaenoptera edeni)*

The Bryde's whale is currently protected under CITES and classified as a data deficient species by the IUCN. There are no global estimates for Bryde's whale. In the Western North Pacific and Western South Pacific, the population of Bryde's whales is estimated by the International Whaling Commission (IWC) as 20,501 whales (IWC, 2009), while 13,000 whales are estimated in the Eastern North Pacific and Eastern Tropical Pacific (Jefferson et al., 2015; Wade and Gerrodette, 1993). In Hawaiian waters, 798 Bryde's whales have been estimated (Carretta et al., 2015), and in the waters of the Gulf of Mexico, only 33 Bryde's whales are estimated to occur (Waring et al., 2014). 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, 2009; 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, 2009). Bryde's whales migrate seasonally toward the lower latitudes near the equator in winter and to high latitudes in summer (Kato and Perrin, 2009). There is some evidence that Bryde's whales remain resident in areas off South Africa and California throughout the year, migrating only short distances (Best, 1960; Tershy, 1992). Bryde's whales are known to breed off South Africa (Best, 1960, 1975). Recent sightings indicate that the range of Bryde's whales is expanding poleward (Kerosky et al., 2012). 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).

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, 2009). Bryde's whales can dive to a water depth of about 984 ft (300 m) (Kato and Perrin, 2009). The maximum dive time reported for two Bryde's whales was 9.4 min with mean durations of 0.4 to 6 min (Alves et al., 2010).

There is no direct measurement of the hearing sensitivity of Bryde's whales (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 calf-cow 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, eastern tropical Pacific, 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, 2009). Pulsive, frequency- and amplitude-modulated calls with a frequency range of 50 to 900 Hz and 0.4 to 4.5 second duration were recorded off Brazil (Figueiredo, 2014). Although the function of Bryde's whale vocalizations is not known, communication is the presumed purpose.

4.1.5 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 not listed as threatened or endangered under the ESA nor is it categorized as depleted under the MMPA. 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 the 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 available estimate for Omura's whales in the Western North and South Pacific stocks. The stock of Omura's whales that occurs in the Andaman Sea area of the northeast Indian Ocean has been estimated to include 9,176 individuals (IWC, 2016; Wade and Gerrodette, 1993) while the population of the Indian Ocean stock numbers 13,854 individuals (IWC, 1981).

Omura's whales are found in the Sea of Japan, the Solomon Sea, and the northeastern Indian Ocean (Wada et al., 2003) as well as in the Philippines (Aragones et al., 2010), China, and Australia, although the geographic range is not well established since so few specimens and sightings have been confirmed. The putative range of the Omura's whale is in tropical and subtropical waters of the Indian Ocean, including Madagascar (Cerchio et al., 2015) and the western Pacific Ocean from the Sea of Japan south to Southern Australian and New Caledonia from about 90° to 160°E, including the Solomon Sea, Java Sea, Andaman Sea, Gulf of Thailand, South China Sea, East China Sea, Sea of Japan, and parts of the Philippine Sea (Yamada, 2009). This whale occurs from inshore to oceanic waters (Cerchio et al., 2015; Reilly et al., 2008). Omura's whales are known from sightings, when they have been observed alone or in pairs, and single strandings. Cerchio et al. (2015) reported that there were never more than two individuals in a traditionally defined group but reported that there were often loose aggregations (within a few to several hundred meters apart), which may actually be social units. Cerchio et al. (2015) reported observations of small calves with bent dorsal fins, indicating that they were neonates.

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 these whales produce long (mean duration = 9.2 sec), broadband, amplitude-modulated calls with energy concentrated in the 15 to 50 Hz band, with a rhythmic sequence with 2-3 minute intervals between utterances (Cerchio et al., 2015). Like other mysticetes, 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).

4.1.6 Antarctic Minke Whale (*Balaenoptera bonaerensis*)

The Antarctic minke whale is listed by the IUCN as data deficient. There are no recent population estimates, but this population still continues to be the target of Japanese "scientific whaling". Jefferson et al. (2015) suggest that the population is less than Ruegg et al.'s (2009) estimate of 670,000 whales. An earlier paper provided estimates of 608,000, 766,000, and 268,000 for three different cruises covering the areas south of 60° S (Branch and Butterworth, 2001). The population of Antarctic minke whales occurring off Western Australia has been estimated as 90,000 whales (Bannister et al., 1996).

Diving behavior has been recorded from foraging individuals. Three dive types were identified: short and shallow, under ice, and long and deep. The mean 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).

There is no direct measurement of the hearing sensitivity of Antarctic minke whales (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). Few descriptions of the Antarctic minke whales have been published. Schevill and Watkins (1972) reported intense downsweeps from ~ 130 to 60 Hz for whales in the Antarctic. However, they were not able to discern if these were common or Antarctic minke whales. Antarctic minke whales are known to produce "bio-duck" sounds; short downsweeps between 250 and 100 Hz that are produced in patterns (Risch et al., 2014a).

4.1.7 Common Minke Whale (*Balaenoptera acutorostrata*)

The minke whale is protected under CITES as well as the MMPA and is classified by the IUCN as a least concern (lower risk) species. Common minke whales in the Western North Pacific Ocean are divided into the "O" stock, which ranges from the Okhotsk Sea to the waters off eastern Japan, and the "J" stock, which is located in waters around the Korean peninsula and in the Sea of Japan (Pastene et al., 1998).

The IWC reports a 1992 to 2004 population estimate for the Southern Hemisphere as 515,000 (IWC, 2016). Populations are estimated at least 180,000 in the Northern Hemisphere (Jefferson et al., 2015). U.S. regional stock assessments report 20,741 animals off the Canadian East Coast, which includes the U.S. Atlantic (Waring et al., 2014); 478 animals off the coasts of California, Oregon, and Washington (Carretta et al., 2014); and 1,233 minke whales in the Alaska stock (Allen and Angliss, 2015). The population of the Western North Pacific "O", Western South Pacific, and Hawaii stocks of common minke whales have been estimated as 25,049 individuals (Buckland et al., 1992) while the Western North Pacific "J" stock is estimated to include 893 common minke whales (Pastene and Goto, 1998). Common minke whales in the Northeast Atlantic stock are estimated to include 78,572 individuals (IWC, 2010). A single stock is identified for the Indian Ocean with an estimated population of 257,500 whales (IWC, 2016), though minke whales are considered rare in the northern Indian Ocean (Salm et al., 1993; Sathasivam, 2002).

Minke whales are generally found over continental shelf waters; and in the far north, they are believed to be migratory, and appear to have home ranges in the inland waters of Washington and central California (Dorsey et al., 1990). Similar to other balaenopterids, minke whales migrate during late spring through early fall to higher latitudes where they feed, and to lower latitudes where they breed during the fall and winter (Víkingsson and Heide-Jørgensen, 2015).

The mean speed value for minke whales in Monterey Bay was 4.5 (+/- 3.45) kt (8.3 +/- 6.4 kph) with a mean dive time was 4.43 (+/- 2.7) min (Stern, 1992). Minke whales in the St. Lawrence River performed both 'short' and 'long' dives. Short dives lasted between 2 and 3 min, while long dives ranged from 4 to 6 min (Christiansen et al., 2015).

There is no direct measurement of the hearing sensitivity of minke whales (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). Minke whales produce a variety of sounds, primarily moans, clicks, downsweeps, ratchets, thump trains, and grunts in the 80 Hz to 20 kHz range (Edds-Walton, 2000; Frankel, 2009; Mellinger et al., 2000; Thompson et al., 1979; Winn and Perkins, 1976). The signal features of their vocalizations consistently include low frequency, short-duration downsweeps from 250 to 50 Hz. Thump trains may contain signature information, and most of the energy of 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 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 amplitude modulated and frequency (AM and FM) signal lasting 2 to 10 seconds with frequency ranges from 1 to 5 kHz.

Minke whales alter their behavior in response to mid-frequency (SQS-53C) sonars. The observed vocalization rate decreases significantly. It is not known if this represents movement away from the area or if the animals simply vocalize less (Martin et al., 2015).

Both geographical and seasonal differences have been found among the sounds recorded from minke whales (Risch et al., 2013). Sounds recorded in the Northern Hemisphere, include grunts, thumps, and ratchets from 80 to 850 Hz, and pings and clicks from 3.3 to 20 kHz. Most sounds recorded during the winter consist of 10 to 60 sec sequences of short 100 to 300 microsecond LF pulse trains (Winn and Perkins, 1976; Thompson et al., 1979; Mellinger and Clark, 2000), while Edds-Walton (2000) reported LF grunts recorded during the summer. Similar sounds with a frequency range from 396 to 42 Hz have been recorded in the Saint Lawrence Estuary (Edds-Walton, 2000). Rankin and Barlow (2005) identified two distinct types of boings, which are found in the central and eastern North Pacific. Central-type boings have also been recorded in the Chukchi Sea (Delarue et al., 2013). Individuals within a population also use calls in different proportions (Risch et al., 2014b) and had source levels of 164 to 168 dB re 1μPa @ 1 m (Risch et al., 2014b). The function of the sounds produced by minke whales is unknown, but they are assumed to be used for communication such as maintaining space among individuals (Richardson et al., 1995). The pattern of usage of calls while animals are within acoustic range of other minke whales reinforces the hypothesis that calls can serve to mediate social interactions (Risch et al., 2014b).

4.1.8 Humpback Whale (*Megaptera novaeangliae*)

The humpback whale is currently listed as endangered under the ESA, depleted under the MMPA, protected under CITES, and as a least concern (lower risk) species by the IUCN. After the 2015 status review of the globally occurring humpback whale, NMFS proposed revising and relisting the humpback whale's global status under the ESA. Since this status change is expected to become finalized before the Final Rule in 2017, the status of the humpback whale cites the existing endangered status, but also documents the proposed revised ESA status of the humpback whale DPSs throughout the species's global range. In the proposed changes to the humpback whale's global status, 14 DPSs for the humpback are recognized (Figure 4-1), of which only two would be listed as endangered and two listed as threatened (NOAA, 2015b). The Arabian Sea and Cape Verde/Northwest Africa DPSs are proposed for listing as endangered while the Western North Pacific (WNP) and Central America DPSs are proposed for listing as threatened. NMFS has determined that the remaining 10 global DPSs do not currently warrant listing under the ESA. No critical habitat has been established for the humpback whale.

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). Pike et al, 2010) estimated the population as 11,572 humpbacks in the northeastern Atlantic and Norwegian Basin, which includes humpback whales in the Iceland stock with representatives from both the Cape Verdes-

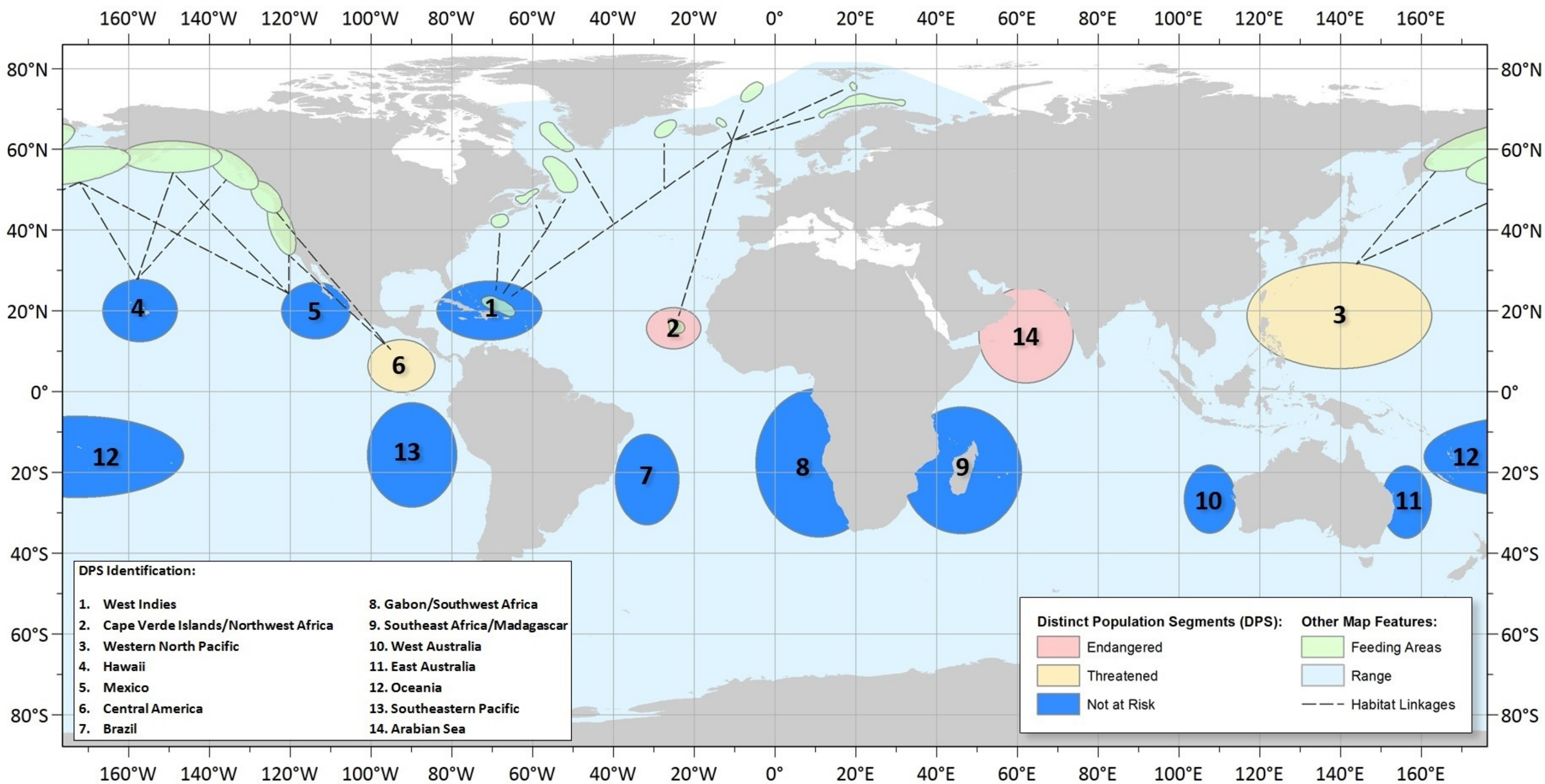

Figure 4-1. The Distinct Population Segments (DPSs) Proposed for Relisting of the Humpback Whale Globally Under the ESA (NOAA, 2015b). These Revisions Would Include Only Two Endangered DPSs, the Arabian Sea and Cape Verde/Northwest Africa, and Two Threatened DPSs, the Western North Pacific and Central America, With all Other DPSs not Proposed for Listing. Image Courtesy of NMFS/NOAA (2015b).

West Africa and West Indies DPSs. The West Indies DPS, including humpback whales from the Gulf of Maine and Newfoundland-Labrador stocks, is estimated as 12,312 individuals (Bettridge et al., 2015). Calambokidis et al. (2008) estimated the population of humpback whales in the entire North Pacific as 18,302 individuals. In the North Pacific Ocean, Carretta et al. (2015) estimated the population of the California/Oregon/Washington stock and Mexico DPS as 1,918 humpback whales; in the Central Pacific stock and Hawaii DPS, 10,103 humpback whales have been estimated to occur (Allen and Angliss, 2015; Calambokidis et al., 2008), with the same number estimated to occur in Gulf of Alaska waters where representative humpbacks from the Western and Central Pacific stocks and Hawaii, Mexico, and WNP DPSs coincide; while the Western North Pacific stock and DPS are estimated to include 1,328 humpback whales (Bettridge et al., 2015). The Southeast Pacific stock/Central America DPS of humpback whales is predicted to include 6,000 individuals (Félix et al., 2011; Johnston et al., 2011) and the population in the IWC Breeding stock E1, or East Australia DPS, is estimated as 14,500 humpback whales (Noad et al., 2011). The Western Australia stock and DPS of humpback whales is calculated to include 13,640 individuals (Bannister and Hedley, 2001), while the Arabian Sea stock and DPS are comprised of 200 humpback whales (Minton et al., 2008; Minton et al., 2011; Rosenbaum et al., 2009).

Humpback whales are distributed throughout the world's oceans, and are only absent from high Arctic and some parts of the equatorial region. They are a highly migratory species that can travel over 4,345 nmi (8,047 km) one way, which is the longest known migration of any mammal (Jefferson et al., 2008). The whales travel to high latitudes in the spring for feeding and to the tropics in the winter for calving and breeding. Humpback whales are found in coastal shelf waters when feeding and close to islands and reefs when breeding (Clapham, 2009). Data indicate that not all animals migrate during the fall from summer feeding to winter breeding sites and that some whales remain year round at high latitudes (Christensen et al., 1992; Clapham et al., 1993; Murray et al., 2013; Straley, 1999). There is also a small non-migratory population in the Arabian Sea (Pomilla et al., 2014). Barco et al. (2002) reported on humpback whale population site fidelity in the waters off the U.S. Mid-Atlantic States. Individual whales have shown a strong fidelity to specific feeding grounds, including the Gulf of Maine, Newfoundland/Labrador, the Gulf of Saint Lawrence, Greenland, Iceland, and Norway. Site fidelity has also been observed in the southern hemisphere feeding grounds (Acevedo et al., 2014). (Barco et al., 2002; Straley, 1999).

Humpback whales have well-defined breeding areas in tropical waters that are usually located near isolated islands. In the North Atlantic, there are breeding areas near the West Indies and Trinidad in the west, and the Cape Verde Islands and off northwest Africa in the east. In the North Pacific, there are breeding grounds around the Mariana Islands, Bonin, Ogasawara, Okinawa, Ryukyu Island, and Taiwan (Clapham, 2009). In the eastern North Pacific, breeding grounds occur around the Hawaiian Islands, off the tip of Baja California, and off the Revillagigedo Islands (Clapham, 2009). Humpbacks in the southern hemisphere are grouped into six management areas based on their summering locations near Antarctica (Donovan, 1991). The relationship between these management areas and actual humpback stocks is still being refined. Summering waters are found throughout the south Pacific, Atlantic and Indian Oceans.

Humpback whales travel long distances, with mean migratory swim speeds between 2.1 to 2.5 kt (3.8 and 4.7 kph) (Gabriele et al., 1996; Horton et al., 2011). Dive times recorded off southeast Alaska are near 3 to 4 min in duration (Dolphin, 1987). In the Gulf of California, humpback whale dive times averaged 3.5 min (Strong, 1990). Dive times on the wintering grounds can be much longer. Singers typically dive between 10 and 25 min. Observations of 20 singers in the Caribbean found dive times between five and 20 min in duration (Chu, 1988). 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).

No direct measurements of the hearing sensitivity of humpback whales 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 by integrating position along the humpback basilar membrane 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. Humpback whales have been observed reacting to LF industrial noises at estimated RLs of 115 to 124 dB (Malme et al., 1985). They have also been observed to react to conspecific calls at RLs as low as 102 dB (Frankel et al., 1995). The presence of seismic survey activity can reduce the number of singing whales (Cerchio et al., 2014).

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). These sounds are attractive and appear to rally animals to the feeding activity (D'Vincent et al., 1985; Sharpe and Dill, 1997). Feeding calls were found to have SLs in excess of 175 dB re 1 μPa @ 1 m (Thompson, et al., 1986; Richardson et al., 1995). Humpback whales in the Northwest Atlantic ocean produce 'Megapclicks', which are click trains and buzzes with most of their energy below 2 kHz (Stimpert et al., 2007). These have a relative low source level of 143 to 154 dB re 1 μPa @ 1 m (peak-peak). While these calls are produced by feeding whales, their function remains unknown.

"Whup" calls are the most common call made by humpback whales in Glacier Bay, AK (Wild and Gabriele, 2014). These calls are composed of a short AM growl followed by a rapid upsweep from 56 to 187 Hz. These calls are thought to serve a communicative function. Additional social sounds have been described from Frederick Sound, AK, ranging from 70 to 3500 Hz and having mean durations from 0.8 to 16.7 seconds (Fournet et al., 2015). Social sounds produced in the Gulf of Marine had similar characteristics (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). These sounds are associated with agonistic behaviors from males competing for dominance and proximity to females. They are known to elicit reactions from animals up to 7.5 km (4.0 nmi) away (Tyack and Whitehead, 1983). Calves produce short, low-frequency sounds (Zoidis et al., 2008).

Migrating humpback whales also produced social sounds. (Dunlop et al., 2007) reported 34 types of calls ranging from 30 to 2400 Hz and between 0.2 and 2.5 seconds in duration. Twenty one of these call types were also included in the song. The median source level of social sounds is 158 dB re 1 μPa (range = 12-183) (Dunlop et al., 2013). Migrating humpbacks producing social sounds demonstrated the Lombard effect, which is an increase in the source level in response to increased ambient noise (Dunlop et al., 2014).

During the breeding season, males sing long complex songs with frequencies between 25 and 5,000 Hz. Mean SLs are ~165 dB re 1 μPa at 1 m (broadband), with a range of 144 to 174 dB (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 underwater acoustic monitoring in Glacier Bay National Park, Alaska, has shown that humpback whales sing more frequently in the late summer and early fall than previously thought. A song is a series of sounds in a predictable order. Humpback songs are typically about 15 min long and are believed to be a mating-related display performed only by males. This study showed that humpback whales frequently sing while they are in Glacier Bay in August through November. Songs were not heard earlier than August, despite the presence of whales, nor later than November, possibly because the whales had started to migrate. It is possible that song is not as prevalent in the spring as it is in the late summer and fall; however, whales still vocalize at this time. The longest song session was recorded in November and lasted almost continuously for 4.5 hours, but most other song sessions were shorter. The songs in Hawaiʻi and Alaska were similar within a single year. The occurrence of songs possibly correlates to seasonal hormonal activity in male humpbacks prior to the migration to the winter grounds.

4.1.9 Bowhead Whale (*Balaena mysticetus*)

Until recently, five stocks of bowhead whales were recognized for management purposes: Spitsbergen, Davis Strait, Hudson Bay, Okhotsk Sea, and Bering-Chukchi-Beaufort Seas (or western Arctic) stocks (Rugh et al., 2003). However, recent genetic, tagging, and population-survey research indicates that the Davis Strait and Hudson Bay stocks should be classified as the same (Allen and Angliss, 2010; Heide-Jørgensen et al., 2006). Only the Okhotsk Sea stock of bowhead whales is located in a region where SURTASS LFA sonar operations potentially may be conducted. Currently, bowheads in the Okhotsk Sea stock do not move beyond the confines of the Sea, so this stock remains isolated with no intermingling occurring with the western Arctic stock.

Throughout its range, the bowhead whale is listed under the ESA as endangered and under the MMPA as depleted. While all bowhead stocks are listed on the IUCN Red List, only the Okhotsk Sea stock is considered endangered (Reilly et al., 2008). The pre-whaling abundance of bowhead whales in the Sea of Okhotsk is unknown, but Mitchell's (1977) estimate of about 6,500 bowheads is the most commonly used estimate. The best available abundance estimate for bowhead whales in the Sea of Okhotsk, which is considered mature but small, is 247 bowhead whales (Ivashchenko and Clapham, 2010; Maclean, 2002). The IWC has noted that the Okhotsk Sea stock has shown no significant signs of recovery from whaling exploitation (IWC; 2010).

Bowhead whales are distributed in arctic to sub-arctic waters of the northern hemisphere roughly between 55° and 85°N (Jefferson et al., 2008). Bowheads typically occur in or near sea/pack ice, with their seasonal distribution being strongly influenced by the location of pack ice (Moore and Reeves, 1993). Typically, bowheads move southward in autumn and winter with the advancing ice edge and remain near the ice edge, in polynyas[10], or areas of unconsolidated pack ice. Moving northward in spring and summer, bowheads concentrate on feeding in areas of high zooplankton abundance.

Bowhead whales occur year-round in the Sea of Okhotsk, but it is not clear if any predictable seasonal movements occur in this stock (Braham, 1984; Ivashchenko and Clapham, 2010). Currently, bowhead

10 Polynya=a Russian word that means ice clearing and refers to an area of open water that is surrounded by sea or landfast ice.

whales are found only in the northern Sea of Okhotsk, with the following principal regions of occurrence in the northwestern and northeastern sea: Shantar region (including Academy, Tugurskiy, Ulbanskiy, and Nikolay Bays) to the Kashevarova Bank (located between Sakalin and Iona Islands), Shelikhov Bay, and Gizhiginskaya Bay; formerly, bowhead occurrence ranged as far northward as Penzhinskaya Bay (Braham, 1984; Ivashchenko and Clapham, 2010; Rice, 1998; Rogachev et al., 2008). Bowheads have been observed in the northern sea in January and February; winter sightings so far north have lead to the speculation that some bowheads may spend the winter among the ice (Ivashchenko and Clapham, 2010). By summer and into early fall (June through September), most sightings of bowhead whales have occurred in northwestern Okhotsk Sea in the Shantar region (Rogachev et al., 2008; Ivashchenko and Clapham, 2010). Unlike other regions, bowheads occupy areas that are ice-free during summer in the Sea of Okhotsk (Reilly et al., 2012). In the joint Japanese-Russian summer sighting surveys from 1989 through 2002 across the entire Okhotsk Sea, including the southern sea, Miyashita et al. (2005) report that no bowhead whales were observed.

Dive behavior of bowhead whales varies widely by season, feeding depth, and life history stage (age and reproductive status) but exhibits no diel pattern (Heide-Jørgensen et al., 2003; Krutzikowsky and Mate, 2000; Thomas et al., 2003). Bowheads are excellent divers, capable of remaining submerged for 61 minutes and diving to depths as deep as 416 m (1,365 ft) (Krutzikowsky and Mate, 2000; Heide-Jorgensen et al., 2003). Dive depth while foraging changes seasonally, in response to changes in copepod distribution (Heide-Jørgensen et al., 2013). Early in the season, bowheads in Disko Bay feed near the seafloor at depths of 328 to 1,312 ft (100 to 400 m). Later in the season, they fed on a copepod layer near 98 ft (30 m). The majority of bowhead dives appear to be shallow and short dives, at depths ≤53 ft (≤16 m) for a mean duration of 6.9 to 14.1 min (Krutzikowsky and Mate, 2000). Heide-Jorgensen et al. (2003) reported that fewer than 15 percent of all recorded bowhead dives were to depths greater than 499 ft (152 m) and only 5 percent of the dives lasted more than 24 min. Averaging about 0.6 to 3 kt (1.1 to 5.8 kph), bowhead whales are fairly slow swimmers (Mate et al., 2000). They can, however, travel vast distances, with one tagged bowhead whale having traveled 1,828 nmi (3,386 km) in 33 days at an overall swim speed of 2.7 kt (5 kph) (Mate et al. 2000).

Knowledge of mysticete hearing is very limited. No direct physiological or behavioral measurements of bowhead whale hearing have been made (Ketten, 1997). Norris and Leatherwood (1981) described the unique auditory morphology of the bowhead whale and determined that bowhead whales are adapted to hear frequencies ranging from high infrasonic to low ultrasonic. Mysticete hearing sensitivity is often inferred from behavioral responses to sound and from the vocalization ranges a species uses. Richardson et al. (1995) estimated from observations of behavioral reactions that mysticete whales likely hear sounds predominantly in the 50 to 500 Hz range, while Ketten (2000) reported that baleen whales likely have best hearing in the frequency range where their vocalizations have the greatest energy, below 5 kHz.

Bowhead whales produce a variety of vocalizations that Frankel (2009) classifies in two principal groups: simple low frequency, FM calls, and complex calls. The FM calls, or moans, are typically less than 400 Hz, typically have a duration of <2.5 seconds, and are typified by up-and down-swept, constant FM contours (Au and Hastings, 2008; Frankel, 2009). Cummings and Holliday (1987) measured a mean source level of bowhead moans of 177 dB re 1 µPa @ 1 m. The complex calls are a combination of pulsed, pulsed-tonal, and high calls; high calls have frequencies >400 Hz and sound like a whine, while the pulsed tonal call is both FM and amplitude modulated (AM), and the pulsed call is often <400 Hz but can range to 1,000 Hz with a mixture of pulsed AM and FM pulses (Frankel, 2009). The pulse modulated call has been described as a gargle type sound with a measured peak source level between 152 to 169 dB re 1 µPa @1 m (Cummings and Holliday, 1987). Calls made during migration have been shown to be moderately directional, with received levels 4-5 dB higher 'in front' of the animals than behind them (Blackwell et al., 2012). Calling rates during the summer feeding season varied spatially and temporally, with the highest rates found on the outer continental shelf, vice inner shelf and slope areas (Charif et al., 2013). Bowhead whales are also capable of producing two different sounds at the same time (Tervo et al., 2011; Würsig and Clark, 1993).

Bowheads also emit sequential sounds with repeatable phrases or patterned signals that can be classified as songs; bowhead whales were the second mysticete whale species discovered to produce songs (Au and Hastings, 2008). Bowhead whales sing one to two themes with the songs changing substantially seasonally and annually (Tervo et al., 2009). Bowhead singing has now been recorded in spring, fall, and winter and may be associated with seasonal movements but also courtship behavior (Delarue et al., 2009; Tervo et al., 2009). Previously, recordings have indicated that the same basic song version with considerable individual variability is sung during a year by all bowhead whales in a population or region but more recently, Stafford et al. (2008) and Delarue et al. (2009) have recorded two songs being sung at a given time. Johnson et al. (2014) reported 12 song types recorded during one migration season. Songs are composed of FM and AM components with great variation in tone (Frankel, 2009). Cummings and Holliday (1987) reported that the mean duration of a song was 66.3 seconds, but song bouts, or the repetition of the same song, can last for hours (Delarue et al., 2009; Johnson et al., 2014).

Several purposes for bowhead vocalizations have been suggested including communication and group cohesion. Song is widely considered to serve a reproductive signaling function (e.g., Stafford et al., 2012). Bowhead whales may also use the reverberation of their calls off surface ice to assess ice conditions (location and smoothness) to avoid collisions with thick ice keels or to locate smooth ice that is thin enough to break through to breathe (George et al., 1989).

4.1.10 North Atlantic Right Whale (*Eubalaena glacialis*)

The North Atlantic right whale is listed as endangered under the ESA, depleted under the MMPA, protected under CITES, and as endangered under the IUCN. The eastern North Atlantic right whale stock has not recovered over the last century and is considered extirpated (Waring et al., 2009). The western North Atlantic stock is extremely endangered with the best abundance estimated for 2014 as 476 individual individuals (Waring et al., 2016). Critical habitat for this species is designated under the ESA in two geographic locations off the eastern U.S.: 1) Southeast U.S. coastal waters between southern Georgia and northern Florida; 2) Northeastern U.S. waters of the Great South Channel (and southern Gulf of Maine) and Cape Cod and Massachusetts Bays (NOAA, 1994). In 2016, critical habitat for the North Atlantic right whale was expanded to include a total of 29,763 nmi^2 (102,084 km^2) of habitat in the Gulf of Maine and Georges Bank area as well as off the southeast U.S. Atlantic coast. The southern critical habitat area was expanded by 341 nmi^2 (1,170 km^2) and includes nearshore and offshore waters from Cape Fear, NC south to ~27 nmi (50 km) south of Cape Canaveral, FL (NOAA, 2016b).

North Atlantic right whales are found in temperate to subpolar waters of the North Atlantic Ocean (Jefferson et al., 2015). They are most commonly found around coastal and continental shelf waters of the western North Atlantic from Florida to Nova Scotia (Kenney, 2009). From late fall to early spring, right whales breed and give birth in temperate shallow areas (Foley et al., 2011), and then migrate into higher latitudes where they feed in coastal waters during the late spring and summer. Right whales have been known to occasionally move offshore into deep water, presumably for feeding (Mate et al., 1997). North Atlantic right whales calve between the northeast coast of Florida and southeastern Georgia and forage in the Bay of Fundy (IFAW, 2001; Vanderlaan et al., 2003). Right whales are found off New Jersey in all seasons of the year (Whitt et al., 2013). The Gulf of Maine has been proposed as a mating ground (Cole et al., 2013). Whales are detected acoustically throughout the winter in this region (Bort et al., 2015). These recent data suggest that the seasonal movements of right whales are more complex than originally thought.

Mate et al. (1997) studied satellite-monitored movements of North Atlantic right whales in the Bay of Fundy. Of the nine whales tracked, six whales left the Bay of Fundy at least once and had an average speed of 1.9 kt (3.5 kph), while those that remained in the Bay of Fundy had a swim speed average of 0.6 kt (1.1 kph). The three whales that did not leave the Bay of Fundy still traveled more than 1,080 nmi (2,000 km) before returning to their original tagging area. All of these whales were in or near shipping lanes and moved along areas identified as right whale habitat (Mate et al., 1997). Baumgartner and Mate (2003) studied diving behavior of foraging North Atlantic right whales in the lower Bay of Fundy and found that the average foraging dive time was 12.2 min, with a maximum dive of 16.3 min. The average dive depth for foraging dives was 398 ft (121 m), with a maximum depth of 571 ft (174 m). Whales foraging in Cape Cod Bay spent most of their time within 8.2 ft (2.5 m) of the surface, a behavior that increases their vulnerability to ship strike (Parks et al., 2011). However, the maximum dive depth recorded by North Atlantic right whales was 1,004 ft (306 m) (Mate et al., 1992). Whales in the Florida winter ground had an average speed of 0.7 kt (1.3 kph), with a range of 0.03 to 2.9 kt (0.05 to 5.37 kph) (Hain et al., 2013).

No direct measurements of the hearing sensitivity of right whales exist (Ketten, 2000; Thewissen, 2002). However, thickness or width measurements of the basilar membrane suggest their hearing range is 10 Hz to 22 kHz, based on established marine mammal models (Parks et al., 2007). North Atlantic right whales produce LF moans with frequencies ranging from 70 to 600 Hz (Vanderlaan et al., 2003). Lower frequency sounds characterized as calls are near 70 Hz. Broadband sounds have been recorded during surface activity and are termed "gunshot sounds" (Clark, 1982; Matthews et al., 2001). These gunshot sounds are produced only by males, and are thought to be a reproductive signal, possibly attracting females (Parks et al., 2005). Parks and Tyack (2005) describe North Atlantic right whale vocalizations from surface active groups (SAGs) recorded in the Bay of Fundy, Canada. The call-types defined in this study included screams, gunshots, blows, up calls, warbles, and down calls and were from 59 whale sounds measured at ranges between 31 to 656 ft (40 and 200 m), with an average distance of 289 ft (88 m). The SLs for the sounds ranged from 137 to 162 dB for tonal calls and 174 to 192 dB for broadband gunshot sounds.

4.1.11 North Pacific Right Whale (*Eubalaena japonica*)

The North Pacific right whale is listed as endangered under the ESA, depleted under the MMPA, and protected under CITES. The North Pacific right whale is also classified as endangered under the IUCN. The population of the Eastern North Pacific right whale stock is estimated as 31 individuals (Muto et al., 2016), while the population of the Western North Pacific right whale stock is much larger, estimated as 922 individuals (Best et al., 2001).

The North Pacific right whale is not a very well known species because there are so few left. This whale population is primarily sighted in the Sea of Okhotsk and the eastern Bering Sea (Jefferson et al., 2015). They have also been seen southeast of the Kamchatka peninsula (Sekiguchi et al., 2014). Passive acoustics and satellite tracking led to the observation of 17 individuals in the eastern Bering Sea in 2004 (Wade et al., 2006). Passive Acoustic monitoring detected North Pacific right whales in deep oceanic waters in the Gulf of Alaska (Širović et al., 2015), suggesting that their current range may be larger than previously thought. Breeding grounds for this species are unknown. The historical range has been predicted based on whaling records and available climate information (Gregr, 2011). From historic records, North Pacific right whales were recorded in offshore waters with a northward migration in the spring and southward migration in autumn (Jefferson et al., 2008). There is no swim speed or dive information 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. This study 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. The down-up call swept down in frequency for 10 to 20 Hz before it became a typical up call. The down calls were typically interspersed with up calls. Constant calls were also interspersed with up calls. 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) .The source level of North Pacific Right whale upcalls averaged 176 to 178 dB re 1μPa @ 1 m, with a frequency range of 90 to 170 Hz (Munger et al., 2011).

4.1.12 Southern Right Whale (*Eubalaena australis*)

The southern right whale is listed as endangered under the ESA, depleted under the MMPA, and protected under CITES. The southern right whale is also classified as a least concern (lower risk) species under the IUCN. The population size is estimated to be around 8,000 whales with an annual growth rate of 7 to 8 percent (Jefferson, et al., 2015).

Southern right whales have a circumpolar distribution in the Southern Hemisphere, predominately found off Argentina, South Africa, and Australia (Kenney, 2009). Major breeding areas include southern Australia, South America along the Argentine coast, and along the southern coast of South Africa (Croll et al., 1999). There is evidence that southern right whales are expanding their range as the population recovers (Carroll et al., 2014; Groch et al., 2005). No swimming or diving information is available for the southern right whale, but like other right whales, 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 or width measurements of the basilar membrane suggest their hearing range is 10 Hz to 22 kHz, based on established marine mammal models (Parks et al., 2007). Southern right whales produce a great variety of sounds, primarily in the 50 to 500 Hz range, but they also exhibit higher frequencies near 1,500 Hz (Cummings et al., 1972; Payne and Payne, 1971). "Up" sounds are tonal FM calls from 50 to 200 Hz that last approximately 0.5 to 1.5 sec and are thought to function in long-distance contact (Clark, 1983). Tonal downsweeps are also produced by this species. Sounds are used as contact calls and for communication over distances of up to 5.3 nmi (10 km) (Clark, 1980, 1982, 1983). For example, females produce sequences of sounds that appear to attract males into highly competitive mating groups. Maximum SLs for calls have been estimated at 172 to 187 dB (Cummings, et al. 1972; Clark, 1982).

4.1.13 Pygmy Right Whale (*Caperea marginata*)

The pygmy right whale is protected under CITES and classified as least concern (lower risk) under IUCN. No data are available on the abundance of this species. Very little is known about the pygmy right whale, as less than 25 sightings of this species have been recorded (Kemper, 2009).

The pygmy right whale is found in the Southern Hemisphere of the Atlantic, Pacific, and Indian oceans, generally north of the Antarctic Convergence (Jefferson et al., 2008). It has been recorded in coastal and oceanic regions, including areas of southern Africa, South America, Australia, and New Zealand. Pygmy right whales occur in Tasmania throughout the year and during the southern winter off South Africa, particularly between False Bay and Algoa Bay (Evans, 1987; Leatherwood and Reeves, 1983). There is some evidence for an inshore movement in spring and summer, but no long-distance migration has been documented. There is no available literature on locations of breeding areas or mating and calving seasons (Baker, 1985; Lockyer, 1984; Ross et al., 1975). Records show this species swims at a speed of 2.9 to 5.1 kt (5.4 to 9.4 kph) and dives up to 4 min (Kemper, 2009). There is no information available on the dive depths of pygmy right whales.

There is no direct measurement of the hearing sensitivity of pygmy right whales (Ketten, 2000; Thewissen, 2002). Sounds produced by one solitary captive juvenile were recorded from 60 to 300 Hz (Dawbin and Cato, 1992). This animal produced short thump-like pulses between 90 and 135 Hz with a downsweep in frequency to 60 Hz. No geographical or seasonal differences in sounds have been documented. Estimated SLs were between 153 and 167 dB re 1 μPa @ 1 m (Frankel, 2009).

4.1.14 Gray Whale (*Eschrichtius robustus*)

The gray whale population is divided into two different stocks and DPSs. The Eastern North Pacific stock and DPS of gray whales was listed as endangered under the ESA, but was de-listed in 1994. The Western North Pacific stock and DPS is extremely small and remains listed as endangered under the ESA. Eastern North Pacific gray whales are protected under CITES and classified as a least concern (lower risk) species under the IUCN, while the Western North Pacific population is considered critically endangered under the IUCN. The Western North Pacific stock/DPS was thought to be extinct, but a small group of gray whales still remain. There are 165 individuals in the Western North Pacific gray whale photo-identification catalog (Tyurneva et al., 2010) but the current population is estimated as 140 individuals (Carretta et al., 2015). The Eastern North Pacific stock of gray whales is estimated to contain 20,990 individuals (Carretta et al., 2015). Western gray whales have been re-sighted off North America (Weller et al., 2012) and have been satellite tracked from Russia to America (Mate et al., 2015). These results suggest that there may be genetic interchange between the two populations.

Gray whales are confined to the shallow coastal waters of the North Pacific Ocean and adjacent seas. They are found as far south as the Baja of California in the eastern North Pacific, and to southern China in the western North Pacific (Jefferson et al., 2015). A foraging region for western gray whales has been identified along the Chukotka peninsula (Heide-Jørgensen et al., 2012). This is in close proximity to some of the eastern gray whale foraging areas along the Alaskan coasts. Every year most of the population makes a large north-south migration from high latitude feeding grounds to low latitude breeding grounds. Most gray whales in the eastern Pacific breed or calve during the winter in lagoons of Baja California (Jones and Swartz, 2009). There is no available information on breeding and calving areas of the western North Pacific gray whale, although Hainan Island has been suggested as a possible location (Brownell and Chun, 1977).

Swim speeds during migration average 2.4 to 4.9 kt (4.5 to 9 kph) and when pursued may reach about 8.64 kt (16 kph) (Jones and Swartz, 2009). Gray whales generally are not long or deep divers. Traveling-dive times are 3 to 5 min with prolonged dives from 7 to 10 min, with a maximum dive time of 26 min, and a maximum dive depth recorded at 557 ft (170 m) (Jones and Swartz, 2009).

There are sparse data on the hearing sensitivity of gray whales. 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. However, this response extinguished 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, potentially up to 12 kHz (Jones and Swartz, 2009). The most common sounds recorded during foraging and breeding are knocks and pulses in 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, 2009). The seasonal variation in the sound production is correlated with the different ecological functions and behaviors of the gray whale. Whales make the least amount of sound when dispersed on the feeding grounds and are most vocal on the breeding-calving ground. The SLs for these sounds range between 167 and 188 dB (Frankel, 2009).

4.2 Odontocetes

Six families containing 60 species of odontocete cetaceans have been assessed for potential impacts due to operation 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 recent hearing thresholds measuring between 400 Hz and 100 kHz (Finneran et al., 2002). 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 echolocation signals as high as 150 kHz (Würsig and Richardson, 2009). Little is known about the details of most sound production and auditory thresholds for many species (Frankel, 2009).

4.2.1 Sperm Whale (*Physeter macrocephalus*)

The sperm whale is currently endangered under the ESA, depleted under the MMPA, classified by IUCN as vulnerable, and classified as protected under CITES. The global population of sperm whales is unknown, but Jefferson et al. (2015) reports an estimate of 360,000 individuals. Sperm whale stocks in the Pacific Ocean have been estimated as 22,700 whales for the eastern tropical Pacific (ETP) (Wade and Gerrodette, 1993); 102,112 individuals in the North and Western South Pacific (Kato and Miyashita, 1998); 3,354 whales in Hawaii (Bradford et al., 2013; Carretta et al., 2014); and 2,106 individuals in California/Oregon/Washington (Carretta et al., 2015). Moore and Barlow (2014) examined abundance trends in sperm whale populations from 1991 to 2008 in the Northeast Pacific and were unable to precisely estimate overall trends but reported a high probability that the numbers of small groups was increasing. In the Atlantic Ocean, sperm whale stocks are estimated to include 763 in the U.S. Gulf of Mexico (Waring et al., 2016); 2,288 in the Western North Atlantic (Waring et al., 2014); and 7,785 in the Eastern North Atlantic (Christensen et al., 1992; Gunnlaugsson and Sigurjonsson, 1990; Whitehead, 2002). Indian Ocean sperm whale stocks have been reported as 24,446 individuals in the Northern and Southern Indian Ocean (IWC, 2016; Perry et al., 1999; Wade and Gerrodette, 1993). The Mediterranean Sea population is estimated by Rendell et al. (2014) to consist of 396 sperm whales.

Sperm whales are primarily found in deeper (>1000 m [3,280 ft]) ocean waters and distributed in polar, temperate, and tropical zones of the world (Reeves and Whitehead, 1997). They have the largest range of all cetaceans, except killer whales (Rice, 1989), but are commonly found near the equator and in the North Pacific (Whitehead, 2009). The distribution of sperm whales is not uniform, but clumped in relation to oceanographic features (summarized in Wong and Whitehead, 2014). 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, especially in the equatorial areas (Whitehead, 2009). The sperm whale has a prolonged breeding season extending from late winter through early summer. In the Southern Hemisphere, the calving season is between November and March (Simmonds and Hutchinson, 1996), although specific breeding and foraging grounds are not well known for this species.

Swim speeds of sperm whales generally range from 2.2 kt (2.6 to 4 kph) (Watkins et al., 2002; Whitehead, 2009). Dive durations range between 18.2 to 65.3 min (Watkins et al., 2002). Sperm whales may be the longest and deepest diving mammals with recorded dives to 4,921 ft (1,500 m) (Davis et al., 2007), but stomach content evidence suggests that sperm whales may dive as deep as 10,498 ft (3,200 m) (Clarke, 1976). Foraging dives typically last about 30 to 40 min and descend to depths from 984 to 4,085 ft (300 to 1,245 m) (Papastavrou et al., 1989; Wahlberg, 2002).

Recent audiograms measured from a sperm whale calf suggest an auditory 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 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). Distinctive coda repertoires have shown evidence of geographical variation among female sperm whales (Weilgart and Whitehead, 1997; Whitehead, 2009). SELs of clicks have been measured between 202 and 236 dB (Madsen and Møhl, 2000; Muhl et al., 2000; Muhl et al., 2003; Thode et al., 2002). Muhl et al. (2000) reported results from recordings of sperm whales at high latitudes with a large-aperture array that were interpreted to show high directionality in their clicks, with maximum recorded SLs greater than 220 dB. Møhl et al. (2003) further described the directionality of the clicks and show that the source levels of clicks differ significantly with aspect angle. This is dependent on the direction that the click is projected and the point where the click is received. The maximum SL for any click in these recordings was 236 dB with other independent events ranging from 226 to 234 dB (Møhl, 2003).

Zimmer et al. (2005b) discuss the three-dimensional beam pattern of regular sperm whale clicks. Regular clicks have several components including a narrow, high-frequency sonar beam to search for prey, a less-directional backward pulse that provides orientation cues, and a low-frequency component of low directionality that conveys sound to a large part of the surrounding water column with a potential for reception by conspecifics at large ranges. The click travel time was used to estimate the acoustic range of the whale during its dives. In this study, the SL of the high-frequency sonar beam in the click was 229 dB (peak value). The backward pulse had an SL of 200 dB (peak value). The low-frequency component immediately followed the backward pulse and had a long duration, with peak frequencies that are depth dependent to over 1,640 ft (500 m). Zimmer et al. (2005b) propose that the initial backward pulse is produced by the phonic lips and activates air volumes connected to the phonic lips, which generate the low-frequency component. The two dominant frequencies in the low-frequency component indicate either one resonator with aspect-dependent radiation patterns or two resonators with similar volumes at the surface but different volumes at various depths. Most of the energy of the initial backward-directed pulse reflects forward off the frontal sac into the junk and leaves the junk as a narrow, forward-directed pulse. A fraction of that energy is reflected by the frontal sac back into the spermaceti organ to generate higher-order pulses. This forward-directed pulse is well suited for echolocation.

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

Both the pygmy sperm whale and dwarf sperm whale are listed as data deficient under the IUCN. Abundance estimates of the global population sizes for these species are unknown but sometimes population information is combined for both species due to the difficulty in distinguishing between the species. Jefferson et al. (2015) reported that an estimated 11,200 dwarf sperm whales occur in the ETP (Wade and Gerrodette, 1993), while 579 pygmy sperm whales are estimated to occur in the California/Oregon/Washington stock, and 17,519 dwarf sperm and 7,138 pygmy sperm whales occur in the Hawaii stocks (Barlow, 2006; Carretta et al., 2014). The population of both species has been estimated as 350,553 whales in the Western North Pacific (Ferguson and Barlow, 2001 and 2003). An estimated 579 pygmy sperm whales are found off the U.S. Pacific coast (Carretta et al., 2014). In the Western and Eastern North Atlantic, an estimated 3,785 *Kogia* spp. occur while 186 are estimated occurring in the Gulf of Mexico (Waring et al., 2014). The stocks of pygmy and dwarf sperm whales in the Indian Ocean 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. They are especially common 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). Breeding areas for both species include waters off Florida (Evans, 1987). There is little evidence that pygmy and dwarf sperm whales have a seasonal migration pattern (McAlpine, 2009).

Swim speeds vary and were found to reach up to 5.9 kt (11 kph) (Scott et al., 2001). 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 Mexico exhibited a maximum dive time of 43 min (Breese and Tershy, 1993; Willis and Baird, 1998).

There are sparse data on the hearing sensitivity for pygmy sperm whales. An ABR study on a rehabilitating pygmy sperm whale indicated that this species has an underwater hearing range that is most sensitive between 90 and 150 kHz (Carder et al., 1995; Ridgway and Carder, 2001). No hearing measured hearing data are available for the dwarf sperm whale. Recent recordings from captive pygmy sperm whales indicate that 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 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. No geographical or seasonal differences in sounds have been documented. Estimated source levels were not available.

4.2.3 Baird's Beaked Whale *(Berardius bairdii)* and Arnoux's Beaked Whale *(Berardius arnuxii)*

Both the Baird's and Arnoux's beaked whales are currently classified as data deficient under the IUCN. Abundance estimates of the global population size for either species are unknown. The abundance of both species has been estimated as 5,029 whales off the Pacific coast of Japan, 1,260 whales in the eastern Sea of Japan, and 660 in the southern Sea of Okhotsk (Kasuya, 2009). Baird's beaked whale population numbers are estimated at 1,100 in the eastern North Pacific, including 847 Baird's beaked whales in the waters of Washington, Oregon, and California (Jefferson et al., 2008; Caretta et al., 2014), 847 whales in Alaska (Allen and Angliss, 2015; Carretta et al., 2015), and 8,000 whales in the Western North Pacific (Kasuya, 1986).

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). Arnoux's beaked whales are distributed in waters surrounding Antarctica, northern New Zealand, South Africa, and southeast Australian. Both species 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. No data are available to confirm seasonal migration patterns for Arnoux's beaked whales, and no data are available for breeding and calving grounds of either species.

Few swim speed data are available for any beaked whale species. 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). Arnoux's beaked whales have a dive time ranging from 10 to 65 min and a maximum of 70 min when diving from narrow cracks or leads in sea ice near the Antarctic Peninsula (Hobson and Martin, 1996). No dive depths are available for Arnoux's beaked whale.

There is no direct measurement of auditory threshold for the hearing sensitivity of either Baird's or Arnoux's beaked whales (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). Arnoux's beaked whales were recorded off Kemp Land, Antarctica, producing sounds between 1 and 8.7 kHz (Rogers and Brown, 1999). Both species produced 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. Estimated SLs are not documented.

4.2.4 Shepherd's Beaked Whale (*Tasmacetus shepherdi*)

The Shepherd's beaked whale is currently classified as a data deficient species by IUCN. Abundance estimates of this species are not available. Shepherd's beaked whales are distributed in cold temperate to polar seas of the Southern Hemisphere including the waters of Antarctica, Brazil, Galapagos Islands, New Zealand, Argentina, Australia, and the South Sandwich Islands (Mead, 2009). No data are available to confirm seasonal migration patterns for Shepherd's beaked whales, and there are no known breeding or calving grounds.

No data are available on swim speeds, dive times, or dive depths for Shepherd's beaked whales. There is no direct measurement of auditory threshold for the hearing sensitivity of Shepherd's beaked whales (Ketten, 2000; Thewissen, 2002). No data are available on sound production for this species.

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

Cuvier's beaked whale is currently classified as a least concern (lower risk) species by the IUCN. Global population estimates for this species are unknown. Abundances of Cuvier's beaked whales are estimated for the ETP as 20,000 individuals (Wade and Gerrodette, 1993); for the eastern North Pacific as 90,000 whales (Barlow, 1995); and as 90,725 whales in the Western North and Western South Pacific (Ferguson and Barlow, 2001 and 2003). The California/Oregon/Washington and Alaska stocks of Cuvier's beaked whales have been estimated most recent as 6,590 individuals, while 1,941 individuals are estimated for Hawaiian EEZ waters (Bradford et al., 2013; Caretta et al., 2014). The best abundance estimate for pooled beaked whales in the western North Atlantic is 6,532 whales (Waring et al., 2014). In the Alboran Sea stock of the Mediterranean, 429 Cuvier's beaked whales are estimated (Cañadas and Vázquez, 2014). The northern Indian Ocean stock of Cuvier's beaked whales is estimated to include 27,222 individuals (Wade and Gerrodette, 1993) while the stock off Western Australia in the Southern Indian Ocean is estimated to include 76,500 individuals (Dalebout et al., 2005).

Cuvier's beaked whales are widely distributed in oceanic tropical to polar waters of all oceans except the high polar areas (Heyning and Mead, 2009). This species is also found in enclosed seas such as Gulf of Mexico, Gulf of California, Caribbean Sea, Mediterranean Sea, Sea of Japan, and the Sea of Okhotsk (Jefferson et al., 2008; Omura et al., 1955). The Cuvier's beaked whale is the most cosmopolitan of all beaked whale species. The Cuvier's apparently prefers waters over the continental slope. No data on breeding and calving grounds are available.

Swim speeds of Cuvier's beaked whale have been recorded between 2.7 and 3.3 kt (5 and 6 kph) (Houston, 1991). 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 and can reach depths of 6,194 ft (1,888 m) (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.

There is no direct measurement of auditory threshold for the hearing sensitivity of Cuvier's beaked whales (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.

4.2.6 Northern Bottlenose Whale *(Hyperoodon ampullatus)* and Southern Bottlenose Whale *(Hyperoodon planifrons)*

The IUCN classifies the status of northern bottlenose whales as data deficient while southern bottlenose whales are currently classified as least concern (lower risk). The Scotian Shelf population of northern bottlenose whales was listed as endangered under Canada's Species at Risk Act (SARA). Both species are also protected under CITES. Abundance estimates of the global populations are unknown. An estimated 40,000 northern bottlenose whales occur in the North Atlantic Ocean, with over 5,000 northern bottlenose whales estimated to occur in the Faroe Islands (Whitehead et al., 1997). The Davis Strait stock of northern bottlenose whales off eastern Canada is estimated to include 50 whales (DFO, 2011; Whitehead and Hooker, 2012) while the Eastern North Atlantic stock is estimated as 19538 whales (Cañadas et al., 2011). There are an estimated 500,000 southern bottlenose whales south of the Antarctic Convergence, making them the most common beaked whale sighted in Antarctic waters (Jefferson et al., 2008). In the Indian Ocean, an estimated 599,300 southern bottlenose whales occur (Kasamatsu and Joyce, 1995).

The northern bottlenose whale is found only in the cold temperate to subarctic waters of the North Atlantic from New England to southern Greenland and the Strait of Gibraltar to Svalbard (Jefferson et al., 2008). This oceanic species occurs seaward of the continental shelf in waters deeper than 500 m (1,640 ft) (Leatherwood and Reeves, 1983; Jefferson et al., 2008). Northern bottlenose whales are commonly found foraging in the Gully, off the coast of Nova Scotia, Canada (Gowans, 2009). The Scotian Shelf population appears to be non-migratory, unlike other northern bottlenose whale populations. The Labrador population migrates to the southern portion of their range, between New York and the Mediterranean, for the winter months. Calving and breeding grounds are unknown.

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.

General swim speeds for ziphiids average 2.7 kt (5 kph) (Kastelein and Gerrits, 1991). Hooker and Baird (1999) documented northern bottlenose whales with regular dives 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 have been recorded close to 70 min. Southern bottlenose whales have been observed diving from 11 to 46 min, with an average duration of 25.3 min (Sekiguchi et al., 1993). 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).

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.

4.2.7 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. Global abundance estimates of this species are not available but 4,571 Longman's beaked whales are estimated to occur in the Western and Central (Hawaii) North Pacific and Western South Pacific stocks (Bradford et al., 2013), 25,300 whales are estimated in the ETP (Wade and Gerrodette, 1993) and 16,867 whales are estimated to occur in the Indian Ocean (Wade and Gerrodette, 1993).

The distribution of Longman's beaked whale is limited to the Indo-Pacific region (Leatherwood and Reeves, 1983; Jefferson et al., 2008). Recent whale groups sighted in the equatorial Indian and Pacific Oceans off Mexico and Africa have tentatively been identified as Longman's beaked whales (Ballance and Pitman, 1998; Pitman, 2009a; Pitman et al., 1998). Strandings have occurred in Hawaiʻi and Japan (West et al., 2012; Yatabe et al., 2010). No data are available to confirm seasonal migration patterns for Longman's beaked whales. No data on breeding and calving grounds are available.

No data are available on swim speeds or dive depths. Only a small number of dive times have been recorded from this species. Dive duration in the Longman's beaked whale is 11 to 33 min, possibly up to 45 min (Pitman, 2009a). There is no direct measurement of hearing sensitivity for Longman's beaked whales (Ketten, 2000; Thewissen, 2002). Longman's beaked whales produce burst-pulses and echolocation clicks and pulses. Echolocation clicks are made at 15 and 25 kHz, along with a 25 kHz FM upsweep pulse. Burst-pulses are long sequence of clicks lasting ~ 0.5 seconds (Rankin et al., 2011).

4.2.8 *Mesoplodon* Species

Fifteen species in the *Mesoplodon* genus of beaked whales may occur in the waters in which SURTASS LFA sonar may operate. These species include: Andrew's, Blainville's, Deraniyagala's, Gervais', ginkgo-toothed, Gray's, Hector's, Hubb's, Perrin's, pygmy, Sowerby's, spade-toothed, Stejneger's, strap-toothed, and True's beaked whales (Table 5). The *Mesoplodon* species are very poorly known, difficult to identify to the species level 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. However, an estimated 694 *Mesoplodon* whales in the California/Oregon/Washington stocks (Carretta et al., 2015; Moore and Barlow, 2013) have been documented. In addition, the population of Blainville's beaked whales in the western North Atlantic was estimated as 149 whales (Waring et al., 2015), while 8,032 Blainville's were estimated to occur in the Western North and Western South Pacific (Ferguson and Barlow, 2001 and 2003), 2,338 whales were reported in Hawaii (Bradford et al., 2013; Carretta et al., 2014), and 25,300 Blainville's beaked whales were estimated for the ETP (Wade and Gerrodette, 1993). In the Indian Ocean, 16,687 Blainville's beaked whales are estimated. Other species of Mesoplodon beaked whales have been estimated at populations of 22,799 individuals in the Western North Pacific Ocean (Ferguson and Barlow, 2001 and 2003), while Stejneger's beaked whales were estimated including 8,000 individuals in the Western North Pacific (Kasuya, 1986).

Mesoplodon whales are distributed in all of the world's oceans except for the cold waters of the Arctic and Antarctic. They are normally found in deep (>2,000 m [6,562 ft]) pelagic water or in continental slope waters. Sowerby's and True's beaked whales are found in the temperate waters of the North Atlantic, and True's is also found in the southern Indian Ocean. Hector's beaked whales, Gray's beaked whales, and Andrew's beaked whales are found in the temperate waters of the Southern Hemisphere. Gervais' beaked whale is found in warm, temperate, and tropical waters of the North Atlantic. Pygmy beaked whales and ginkgo-toothed beaked whales are found in tropical warm waters in the Pacific, and the ginkgo-toothed beaked whale is also found in the tropical waters of the Indian Ocean. Stejneger's beaked whale and Hubb's beaked whale are found in the temperate North Pacific, and the Stejneger's beaked whale can also be found in subarctic waters. 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)

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 Hawaiʻi with a maximum rate of 4.4 kt (8.1 kph). Dives of Blainville's beaked whales average 7.5 min during social interactions at the surface (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 species and not well documented. In Hawaiʻi, a Blainville's beaked whale had a maximum dive depth of 4,619 ft (1,408 m), and dive duration from 48 to 68 min (Pitman, 2009b).

Hubb's beaked whale has been recorded producing whistles between 2.6 and 10.7 kHz, and pulsed sounds from 300 Hz to 80 kHz and higher with dominant frequencies from 300 Hz to 2 kHz (Buerki et al., 1989; Lynn and Reiss, 1992). A stranded Gervais' beaked whale had an upper limit for effective hearing at 80 to 90 kHz (Finneran et al., 2009). A stranded Blainville's beaked whale's hearing was tested between 5.6 and 160 kHz. The best hearing response was 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). They also produce a buzz click that is 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).

Studies on Cuvier's beaked whales and Blainville's beaked whales conducted by Johnson et al. (2004) concluded that no vocalizations were detected from any tagged beaked whales when they were within 200 m (656 ft) of the surface. The Blainville's beaked whale started clicking at an average depth of 400 m (1,312 ft), ranging from 200 to 570 m (656 to 1,870 ft), and stopped clicking when they started their ascent at an average depth of 720 m (2,362 ft), with a range of 500 to 790 m (1,640 to 2,591 ft). The intervals between regular clicks were approximately 0.4 second. Trains of clicks often end in a buzz. Both the Cuvier's beaked whale and the Blainville's beaked whale have a somewhat flat spectrum that was accurately sampled between 30 and 48 kHz. There may be 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).

Recordings of Sowerby's beaked whales found echolocation clicks with center frequencies of 33, 25, 51, or 67 kHz (Cholewiak et al., 2013). Most clicks did not have any frequency modulation, although a few showed a slight sweep from 30 to 36 kHz. Burst-pulse signals were also detected, however the occurred much less often than clicks (7 v. 2969).

4.2.9 Beluga Whale (*Delphinapterus leucas*)

The beluga is classified as a near threatened species by the IUCN, and the Cook Inlet stock is a listed as endangered under the ESA (Jefferson et al., 2015; NMFS, 2008). Worldwide abundance is estimated near 150,000; with 39,258 in the Beaufort Sea; 3,710 in the eastern Chukchi Sea; 19,186 in the eastern Bering Sea; 18,142 in Norton Sound; 2,877 in Bristol Bay; 312 in Cook Inlet; 28,000 in Baffin Bay; 25,000 in western Hudson Bay; and 10,000 in eastern Canada (Allen and Angliss, 2015; Jefferson et al., 2015). In the Sea of Okhotsk, 12,226 belugas have been estimated to occur (Shpak and Glazov, 2013).

Beluga habitat is found in both shallow and deep water of the north circumpolar region ranging into the subarctic. Belugas inhabit the east and west coasts of Greenland, and their distribution in North America extends from Alaska across the Canadian western arctic to the Hudson Bay (Jefferson et al., 2008). Occasional sightings and strandings occur as far south as the Bay of Fundy in the Atlantic. Belugas tend to summer in large groups in bays, shallow inlets, and estuaries. Possible reasons include warmer water in the shallow areas, and availability of anadromous fish, such as salmon, capelin, and smelt which are highly abundant in those areas during the summer months (O'Corry-Crowe, 2009). In the Pacific, migratory belugas summer in the Okhotsk, Chukchi, Bering, and Beaufort seas, the Anadyr Gulf, and waters off Alaska (Jefferson et al., 2008). One of the Alaska stocks of beluga whales, the Cook Inlet stock, resides there year-round and is geographically isolated from all other stocks (Hansen and Hubbard, 1999; Rugh et al., 2000) .Little is known about the distribution of beluga whales in the winter, but it is believed that the whales migrate in the direction of the advancing ice front and overwinter near "polynyas" (O'Corry-Crowe, 2009).

The beluga is not a fast swimmer, with maximum swim speeds estimated between 8.6 and 11.9 kt (16 and 22 kph) and a steady swim rate in the range of 1.3 to 1.8 kt (2.5 to 3.3 kph) (Brodie, 1989; O'Corry-Crowe, 2009). Studies on diving capabilities of trained belugas in open ocean conditions by (Ridgway et al., 1984) demonstrated a capacity to dive to depths of 2,123 ft (647 m) and remain submerged for up to 15 min. Most dives fall into either of two categories: shallow surface dives or deep dives. Shallow dive durations of belugas are less than 1 min. Deep dives last for 9 to 18 min, and dive depths range between 984 and 1,968 ft (300 and 600 m). In deep waters beyond the continental shelf, belugas may dive in excess of 3,281 ft (1,000 m), remaining submerged for up to 25 min (O'Corry-Crowe, 2009). Wild belugas were tagged with time-depth recorders (Citta et al., 2013). They found that dives could be categorized into three types. Shallow dives were typically less than 164 ft (50 m). Intermediate dives ranged to 820 (250 m), while deep dives extended to 1,312 ft (400 m). Dive duration typically ranged from 1 to 18 min. They also found regional differences; belugas in the eastern Beaufort Sea dove deeper than those in the western Beaufort or Chukchi seas.

Belugas have hearing thresholds approaching 42 dB RL at their most sensitive frequencies (11 to 100 kHz) with overall hearing sensitivity from 40 Hz to 150 kHz (Au, 1993; Awbrey et al., 1988; Johnson et al., 1989; Ridgway et al., 2001). Awbrey et al. (1988) measured hearing thresholds for three captive belugas between 125 Hz and 8 kHz. They found that the average threshold was 65 dB RL at 8 kHz. Below 8 kHz, sensitivity decreased at approximately 11 dB per octave and was 120 dB RL at 125 Hz. A study by Mooney et al. (2008) found that belugas had a more sensitive hearing threshold than previously thought. The studied whale had a hearing threshold below 60 dB re 1 µPa between 32 and 80 kHz and below 70 dB at 11.2 and 90 kHz (Mooney et al., 2008). Hearing was tested in seven wild belugas using

AEP methodology (Castellote et al., 2014). There was substantial variability in sensitivity between individuals (>30 dB). The lowest hearing thresholds of 35-45 dB were found in the 45 to 80 kHz range. All animals could hear up to 128 kHz, and two were able to hear 150 kHz.

Signals produced by belugas have been described as a graded continuum (Sjare and Smith, 1986), meaning that call types grade continuously into other call types. Belugas produce tonal calls or whistles in the 260 Hz to 20 kHz range and a variety of call types in the 100 Hz to 24 kHz range (Chmelnitsky and Ferguson, 2012). Echolocation clicks extend to 120 kHz (O'Corry-Crowe, 2009; Schevill and Lawrence, 1949; Sjare and Smith, 1986). There are at least 50 different call types, including "groans," "whistles," "buzzes," "trills" and "roars" (O'Corry-Crowe, 2009). Beluga whales are commonly most vocal during milling and social interactions (Karlsen et al., 2002). Predominant echolocation frequencies are bimodal for this species and occur in ranges of 40 to 60 kHz and 100 to 120 kHz at SLs between 206 and 225 dB (Au, 1993; Au et al., 1987). Belugas can also produce vocalizations that incorporate both tonal and pulsed components (Miralles et al., 2012). There is supportive evidence of geographical variation from distinctive calls used for individual recognition among beluga whales (Bel'kovich and Sh'ekotov, 1993).

4.2.10 Killer Whale (*Orcinus orca*)

The killer whale is classified as a data deficient species under the IUCN. In 2005, the NMFS published a final determination to list the Southern Resident killer whales (*Orcinus orca*) DPS as endangered under the ESA (NOAA, 2005). 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, 2005).

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 8,500 killer whales was estimated for the waters of the ETP (Wade and Gerrodette, 1993), with 101 killer whales currently estimated in the Hawaii stock (Bradford et al., 2013; Carretta et al., 2014), 240 killer whales are estimated in the Eastern Pacific Offshore stock (Carretta et al., 2015), and 12,256 whales in the Western North and Western South Pacific stocks (Ferguson and Barlow, 2001 and 2003). Additionally in the eastern North Pacific stock, 2,347 Alaska Resident, 587 Gulf of Alaska/Aleutian Islands/Bering Sea transient, 82 Southern Resident, 261 Northern Resident, 7 AT1 Transient, and 243 West Coast Transient killer whales have been estimated in these sub-stocks (Allen and Angliss, 2015; Carretta et al., 2015). Killer whales in the Sea of Okhotsk, members of the Okhotsk-Kamchatka-Western Aleutians Transient stock, number 12,256 killer whales (Ferguson and Barlow, 2001 and 2003; Carretta et al., 2016). In U.S. Atlantic waters, 28 killer whales are estimated to occur in the northern Gulf of Mexico (Waring et al., 2015), while 76 whales have been estimated to occur in the Western North Atlantic U.S. (Lawson and Stevens, 2014), and the Northern Norway stock of killer whales includes 731 whales (Kuningas et al., 2014). In the Indian Ocean, killer whales number 12,593 individuals (Wade and Gerrodette, 1993).

Nearly 80,000 killer whales are estimated south of the Antarctic Convergence Zone (Jefferson et al., 2008).

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, they 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).

Swimming speeds usually range between 3.2 to 5.4 kt (6 to 10 kph), but they can achieve speeds up to 20 kt (37 kph) in short bursts (Lang, 1966; LeDuc, 2009). 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 depth of 807 ft (246 m). Males dove more often and remained submerged longer than females. They also reported more dives 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 animals 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 and short and shallow, and long and deep. Short dives lasted less than one minute and had dive depths of less than five meters. 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.

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., 1971;Diercks et al., 1973; 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 each pod (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 of the vocal repertoire in comparison to pulsed calls (Miller and Bain, 2000). Erbe (2002) recorded received broadband sound pressure levels of orca burst-pulse calls ranging between 105 and 124 dB RL at an estimated distance of 100 m (328 ft). Offshore killer whales tracked in the Southern California bight had source levels for echolocation clicks of 170-205 dB re 1μPa @ 1 m (peak-peak) (Gassmann et al., 2013). Whistle source levels ranged between 185 and 193 dB re 1 μPa @ 1 m. Pulse call source levels ranged between 146-158 dB re 1μPa @ 1 m. While the basic structure of killer whale vocalizations are similar within all populations, geographic variation between populations does exist (Samarra et al., 2015).

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

4.2.11 False Killer Whale (*Pseudorca crassidens*)

False killer whales are classified as least concern (lower risk) by the IUCN. The Main Hawaiian Island Insular DPS of 151 false killer whales is listed as endangered under the ESA (NOAA, 2012b). The global population for this species is unknown. Estimates of 39,800 whales have been documented in the ETP (Wade and Gerrodette, 1993), while 16,668 whales have been documented in the northwestern and southwestern 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 whales have been estimated as 1,540 whales in the Hawaii pelagic population, as 617 whales in the Northwestern Hawaiian Islands DPS, and 1,329 whales off Palmyra (Bradford et al., 2014 and 2015; Carretta et al., 2016). In the western north Atlantic, there are an estimated 442 false killer whales and an unknown number in the Gulf of Mexico (Waring et al., 2015). 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 in tropical to warm temperate zones in deep, offshore 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). 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 have an approximate swim speed of 3 kph (1.6 kt), although a maximum swim speed has been documented at 28.8 kph (11.9 kt) (Brown et al., 1966; Rohr et al., 2002).

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) with 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 hear underwater sounds in the range of less than 1 to 115 kHz (Au, 1993; Johnson, 1967). Their best underwater hearing occurs at 17 kHz, where the threshold level ranges between 39 to 49 dB RL. In a study by Yuen et al. (2005), false killer whales' hearing was measured using both behavioral and AEP audiograms. The behavioral data show that this species is most sensitive between 16 and 24 kHz, with peak sensitivity at 20 kHz. The AEP data show that this species best hearing sensitivity is from 16 to 22.5 kHz, with peak sensitivity at 22.5 kHz. Au et al. (1997) studied the impacts 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., 2004b; 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., 2004b; Thomas and Turl, 1990).

4.2.12 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 38,900 of pygmy killer whales have been documented in the ETP (Wade and Gerrodette, 1993), while 3,433 whales in the Hawaiian population (Bradford et al., 2013; Carretta et al., 2014) and 30,214 whales in the Western North and South Pacific populations have been estimated (Ferguson and Barlow, 2001 and 2003). An estimated 152 pygmy killer whales were reported in the Gulf of Mexico (Waring et al., 2015) and another 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 (Caldwell, 1971; Donahue and Perryman, 2009). It is 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). It has been seen in the Indian Ocean (De Boer, 2000), the Philippines (Dolar et al., 2006) and stranded off Brazil (de Moura et al., 2010). 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). One document describes pygmy killer whales producing LF “growl” sounds (Pryor et al., 1965).

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. Estimates of 45,400 melon-headed whales have been reported for the ETP (Wade and Gerrodette, 1993), while 36,770 whales have been estimated for the Western North and Western South Pacific Ocean (Ferguson and Barlow, 2001, 2003). In the Northern Mariana Islands, 2,455 melon-headed whales were estimated (Fulling et al., 2011). Two populations have been documented in Hawaiian waters: the pelagic stock with 5,794 whales and the Kohala resident population with an estimated 447 whales (Aschettino, 2010; Carretta et al., 2014; Oleson et al., 2013). An estimate of 2,235 melon-headed whales was reported for the northern Gulf of Mexico (Waring et al., 2015). 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 (Jefferson and Barros, 1997). Breeding areas and seasonal movements of this species have not been confirmed. 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). General swim speeds for this species are not available.

Few data are available on diving or swim speed for the melon-headed whale. 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).

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). The earlier report by Watkins et al. (1997) had an error in species identification (Baird, pers. comm.). 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 Long-finned Pilot Whale (*Globicephala melas*)

The long-finned pilot whale is classified as data deficient by the IUCN. The global population for the long-finned pilot whale is unknown. An estimated 200,000 exist in the Antarctic Convergence (Jefferson et al., 2015). An estimate of 26,535 long-finned pilot whales was reported for the western North Atlantic (Waring et al., 2015); 6,134 whales were estimated in the Canadian East Coast stock (Lawson and Gosselin, 2009 and 2011); and 128,093 whales in the eastern North Atlantic (North Atlantic Marine Mammal Commission [NAMMCO], 2016).

Long-finned pilot whales occur off shelf edges in deep pelagic waters and in temperate and subpolar zones excluding the North Pacific (Nelson and Lien, 1996). There is a high abundance of long-finned pilot whales in the Mediterranean Sea and evidence of an autumn migration near this area (Croll et al., 1999). There is also a seasonal migration evident around Newfoundland that may be correlated to a breeding season lasting from May to November (Nelson and Lien, 1996; Sergeant, 1962).

Pilot whales generally have swim speeds ranging between 1.1 to 6.5 kt (2 to 12 kph) (Shane, 1995b). Long-finned pilot whales have an average speed of 1.8 kt (3.3 kph) (Nelson and Lien, 1996) and are considered deep divers (Croll et al., 1999). Dive depths of long-finned pilot whales range from 52 ft (16 m) during the day to 2,126 ft (648 m) during the night (Baird et al., 2002). Dive duration varied between 2 and 13 min.

Although little information is available on the hearing sensitivity of the long-finned pilot whale, a recent study by Pacini et al. (2010) measured the first audiogram of this species. The AEP-derived audiogram of a rehabilitated stranded long-finned pilot whale showed the U-shaped curve common in other mammals. The audiogram results found best hearing between 11.2 and 50 kHz with thresholds below 70 dB, while best hearing sensitivity was found at 40 kHz with a 53.1 dB threshold (Pacini et al., 2010). Pilot whales echolocate with a precision similar to bottlenose dolphins and vocalize with other school members (Olson, 2009). Pilot whales were able to mimic LF and MF sonar signals, indicating an ability to hear as low as 1 kHz (Alves et al., 2014). Long-finned pilot whales produce sounds, including double clicks and whistles, with frequencies as low as 500 Hz and as high as 18 kHz, with dominant frequencies between 3.5 and 5.8 kHz (Busnel and Dzeidzic, 1966; Mcleod, 1986; Rendell et al., 1999; Schevill, 1964; Steiner, 1981; Taruski, 1979). Sound production of long-finned pilot whales is correlated with behavioral state and environmental context (Frankel, 2009; Taruski, 1979; Weilgart and Whitehead, 1990). For example, signal types described as non-wavering whistles are associated with resting long-finned pilot whales. The whistles become more complex in structure as more social interactions take place (Frankel, 2009). There are no available data regarding seasonal or geographical variation in the sound production of the long-finned pilot whale. Echolocation clicks have a centroid frequency of 55 kHz and a peak-to-peak source level of 196 dB re 1 µPa @ 1 m (Eskesen et al., 2011). Pulsed calls have a complex and variable structure, with a measured frequency range of 140 to 20,000 Hz and durations that range between 0.2 and 2.2 sec (Nemiroff and Whitehead, 2009). It should be noted that the 20 kHz upper limit of these values may be an artifact of the recording equipment, which only recorded between 10 Hz and 20 kHz.

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

The short-finned pilot whale is classified as data deficient by the IUCN. A global population estimate for short-finned pilot whales is unknown. Off the U.S. west coast, the abundance of the California/Oregon/Washington stock has been estimated as 760 individuals (Barlow, 2010; Barlow and Forney, 2007; Carretta et al., 2015; Forney, 2007). Wade and Gerrodette (1993) estimated the population of short-finned pilot whales in the ETP as 160,200, while 53,608 short-finned pilot whales are estimated for the Western North Pacific stock (Miyashita, 1993). Estimates of 2,415 short-finned pilot whales were reported for the Gulf of Mexico with 21,515 whales reported for the Western North Atlantic (Waring et al., 2015). The population in the Indian Ocean has been estimated at 268,751 individuals (Wade and Gerrodette, 1993).

Short-finned pilot whales have a tropical and subtropical distribution (Olson, 2009). There appears to be little seasonal movement of this species. Some short-finned pilot whales stay year round near the California Channel Islands whereas others are found offshore most of the year moving inshore with the movement of squid (Croll et al., 1999). Calving season peaks during the spring and fall in the Southern Hemisphere. No breeding grounds have been confirmed.

Pilot whales generally have swim speeds ranging between 1.1 to 6.5 kt (2 to 12 kph) (Shane, 1995a). 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). 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), 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. Short-finned pilot whales off Kauai produced the majority of their foraging echolocation clicks at night (Au et al., 2013). Two whales that had stranded were equipped with satellite tags and were tracked for 16 and 67 days; 93 percent of their dives were to less than 328 ft (100 m) (Wells, 2013).

AEPs were used to measure the hearing sensitivity of two short-finned pilot whales (Schlundt et al., 2011). This study tested hearing of one captive and one stranded short-finned pilot whale and found the region of best hearing sensitivity for the captive whale to be 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. Their greatest sensitivity was around 20-40 kHz for all whales, with thresholds between 70 and 80 dB re 1µPa. Thresholds at 80 kHz were 25-61 dB higher in the adults than the juveniles (Greenhow et al., 2014).

Pilot whales echolocate with a precision similar to bottlenose dolphins and vocalize with other school members (Olson, 2009). 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 frequency of calls produced by short-finned pilot whales is 7,870 Hz, much higher than the mean frequency of calls 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). 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). Mean click duration was 545 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).

4.2.16 Risso's Dolphin (*Grampus griseus*)

Risso's dolphins are classified as a least concern (lower risk) species by the IUCN. Although no global population abundance exists for the Risso's dolphin, in the waters of the ETP, the Philippines, and off Sri Lanka abundances have been estimated at 110,457 (Gerrodette et al., 2008); 1,500; and 5,550 to 13,000 dolphins, respectively (Jefferson et al., 2015). The Western North and South Pacific as well as Inshore Archipelago populations have been estimated to include 83,289 dolphins (Miyashita, 1993). In the U.S. Pacific Ocean waters, an estimated 6,272 Risso's dolphins occur in the California/Oregon/Washington stock (Barlow, 2010; Carretta et al., 2015; Forney, 2007), while 7,256 dolphins occur in the Hawaiian stock (Bradford et al., 2013; Carretta et al., 2014). An abundance of 18,250 Risso's dolphins has been estimated for the Western and Eastern North Atlantic stocks and 2,442 Risso's dolphins in the northern Gulf of Mexico stock (Waring et al., 2015). Population levels for the UK are estimated at 2,800 (Jefferson et al., 2015) and for the Western Mediterranean Sea at 5,320 (Airoldi et al., 2005; Gomez de Segura et al., 2006). 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, 1993; Leatherwood et al., 1980). They occur predominantly at steep shelf-edge habitats, between 400 and 1,000 m (1,300 and 3,281 ft) deep with water temperatures commonly between 15 and 20°C and rarely below 10°C (Baird, 2009b). They are commonly found in the north-central Gulf of Mexico and in the northwestern Atlantic. Seasonal migrations for Japan and the 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).

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). Risso's dolphins feed predominantly on neritic and oceanic squid species, probably primarily feed at night (Baird, 2009b). Dive times up to 30 min have been reported for this species (Jefferson et al. 2015; Philips et al., 2003).

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 impacts of the ATOC source on false killer whales and on Risso's dolphins. The ATOC source transmitted 75-Hz, 195 dB SL acoustic signal to study ocean temperatures. The hearing sensitivity was measured for Risso's dolphins and their thresholds were found to be 142.2 dB RL $\pm$ 1.7 dB for the 75 Hz pure tone signal and 140.8 dB RL $\pm$ 1.1 dB for the ATOC signal (Au et al., 1997). Another individual had best hearing at 11 kHz, and between 40 and 80 kHz, a response threshold of about 60 dB re 1μPa (Mooney et al., 2015). These values are comparable to those previously reported by (Nachtigall et al., 1995; Nachtigall et al., 2005). Risso's dolphins are able to reduce their hearing sensitivity while echolocating (Nachtigall and Supin, 2008).

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

4.2.17 Short-beaked Common Dolphin (*Delphinus delphis delphis),* and Long-beaked Common Dolphin (*Delphinus delphis bairdii),* and Indo-Pacific Common Dolphin (*Delphinus delphis tropicalis*)

Genetic research has recently assisted in resolving the taxonomy of common dolphins. Three species of common dolphins are included: the Indo-Pacific, the long-beaked, and short-beaked common dolphins. The Indo-Pacific common dolphin is essentially the long-beaked common dolphin of the Indian Ocean (Society for Marine Mammalogy [SMM], 2016). However, the characterizations that define the three 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, the three common dolphin species are presented together herein and long-beaked common dolphin references generally pertain to both species of long-beaked common dolphins.

The short-beaked dolphin is classified as a least concern (lower risk) species, and the long-beaked common dolphin is classified as a data deficient species by the IUCN. The global population for all common dolphin species is unknown. There are little data available on abundance estimates of long-beaked common dolphins. Short-beaked common dolphins are the most abundant species in the ETP at an estimated 3,127,203 dolphins (Gerrodette et al., 2008). In the California/Oregon/ Washington stocks 107,016 long-beaked common dolphins occur, an estimated 411,211 short-beaked common dolphins occur (Barlow, 2010; Carretta et al., 2011; Carretta et al., 2015). In the Western North and Western South Pacific stocks, 3,286,163 short-beaked common dolphins are estimated (Ferguson and Barlow, 2001 and 2003), while 279,182 long-beaked common dolphins are estimated for the Western North Pacific stock (Carretta et al., 2011). Estimates for the western North Atlantic stock of short-beaked common dolphins include 173,486 individuals (Waring et al., 2015), with 172,930 short-beaked common dolphins found in the Eastern North Atlantic (Hammond et al., 2009 and 2013). Cañadas and Hammond (2008) estimated that 19428 short-beaked common dolphins occurred in the Western Mediterranean. Jefferson et al (2015) estimates 15,000 to 20,000 long-beaked dolphins are estimated to occur in South African waters. As many as 1,819,882 long-beaked or Indo-Pacific common dolphins are estimated to occur in the Indian Ocean (Wade and Gerrodette, 1993).

Short-beaked and long-beaked common dolphins are distributed worldwide in temperate, tropical, and subtropical oceans, primarily along continental shelf and steep bank regions where upwelling occurs (Jefferson et al. 2015; Perrin, 2009a). They seem to be most common in the coastal waters of the Pacific Ocean, usually beyond the 656-ft (200-m) isobath and north of 50°N in the Atlantic Ocean (Croll et al., 1999). Long-beaked dolphins, however, seem to prefer shallower, warmer waters that are closer to the coast (Perrin, 2009a). They are often found within 97.2 nmi (180 km) of the coast (Jefferson et al., 2015). Long-beaked common dolphins occur around West Africa, from Venezuela to Argentina in the western Atlantic Ocean, from southern California to central Mexico and Peru in the eastern Pacific Ocean, around Korea, southern Japan, and Taiwan in the western Pacific, and around Madagascar and South Africa. Indo-Pacific common dolphins are only known to occur in the northern Indian Ocean and in Southeast Asia. No breeding grounds are known for common dolphins (Croll et al., 1999). Calving peaks during May and June both in the northeastern Atlantic and North Pacific.

Swim speeds for *Delphinus* spp. have been measured at 3.1 kt (5.8 kph) with maximum speeds of 8.7 kt (16.2 kph); but in other studies, common dolphins have been recorded at swimming up to 20 kt (37.1 kph) (Croll et al., 1999; Hui, 1987). 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).

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, 1980c; 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.

4.2.18 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 Western North and South Pacific stocks, 220,789 Fraser's dolphins are estimated; while in the Central North Pacific stock, including Hawaii, 16,992 dolphins occur (Bradford et al., 2013; Carretta et al., 2015); in the ETP, the Fraser's abundance has been estimated as 289,000 Fraser's dolphins (Wade and Gerrodette, 1993); and in the eastern Sulu Sea the abundance is estimated as 13,518 dolphins (Dolar, 2009). Although the Fraser's dolphin is known to occur rarely in the U.S. Gulf of Mexico, no current abundance estimate is available for this dolphin in the northern Gulf (Waring et al., 2015). 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 (Croll et al., 1999; Dolar, 2009). They are found in the Atlantic, Pacific, and Indian Oceans. This species is an oceanic species that 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 occurs in the Philippines, Taiwan, some Caribbean islands, and the Indonesian-Malay archipelago (Jefferson et al., 2015). Breeding areas and seasonal movements of this species have not been confirmed. However, in Japan, calving appears to peak in the spring and fall. There is some evidence that calving occurs in the summer in South Africa (Dolar, 2009). 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). Several foraging depths have been recorded. 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, they appear to feed near the surface to at least 1,968 ft (600 m). In South Africa and in the Caribbean, they 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. Dive durations are not available.

There is no direct measurement of the hearing sensitivity of Fraser's dolphins (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 FM 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.

4.2.19 Common Bottlenose Dolphin *(Tursiops truncatus)*

Overall, the common bottlenose dolphin is classified as least concern (lower risk) by the IUCN. However, the Fiorldland, NZ population is considered critically endangered and the Mediterranean population is considered vulnerable by the IUCN. The global population for the bottlenose dolphin is unknown. Estimates of 335,834 dolphins have been documented in the ETP (Gerrodette et al., 2008), and an estimated 168,791 bottlenose dolphins occur in the Western North and Western South Pacific stocks (Miyashita, 1993). The Inshore Archipelago stock that occurs in the Asian continental seas includes 105,138 dolphins (Miyashita, 1986 and 1993). Off the Pacific coast of the U.S., 323 coastal and 1,006 offshore bottlenose dolphins were estimated (Carretta et al., 2015). The pelagic Hawaiian population of common bottlenose dolphins includes 5,950 individuals, while the nearshore Hawaiian stocks include 184 dolphins in the Kaua'i/Ni'ihau stock, 743 off O'ahu, 191 in the 4-Island stock, and 128 in the Hawai'i Island stock (Baird et al., 2009; Bradford et al., 2013; Carretta et al., 2015). The Western Mediterranean stock of common bottlenose dolphins is estimated to include 1,676 individuals (Lauriano et al., 2014), 785,585 dolphins are estimated in the Indian Ocean population (Wade and Gerrodette, 1993), and 3,000 bottlenose dolphins may occur off Western Australia (Preen et al., 1997). The Eastern North Atlantic stock of common bottlenose dolphins has been estimated as 35780 individuals (Hammond et al., 2009 and 2013). Population estimates have been derived for each of the stocks of common bottlenose dolphins that occur in the U.S. western North Atlantic and Gulf of Mexico waters (Waring et al., (2015) (Table 4-1).

The bottlenose dolphin is distributed worldwide in temperate to tropical waters. In North America, they inhabit waters with temperatures ranging from 10 to 32°C (50 to 89°F) (Wells and Scott, 2009). They 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). Bottlenose dolphins are found in the Pacific, Atlantic, and Indian oceans. The species' northern range extends to the United Kingdom and northern Europe (Croll et al., 1999). The species' southern range extends as far south as Tierra del Fuego, South Africa, Australia, and New Zealand (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.

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 16.1 kt (29.9 kph) (Croll et al., 1999). Dive times range from 38 sec to 1.2 min but have been known to last as long as 10 min (Mate et al., 1995; Croll et al., 1999). The dive depth of a bottlenose dolphin in Tampa Bay, Florida, was measured at 322 ft (98 m) (Mate et al., 1995). The deepest dive recorded for a bottlenose dolphin is 1,755 ft (535 m) reached by a trained individual (Ridgway, 1986).

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 at 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.,

Table 4-1. Details of the Population Estimates for the U.S. Western North Atlantic and Gulf of Mexico Stocks of Common Bottlenose Dolphins (Waring et al., 2015).

Stock Name	*Population Estimate*
Western North Atlantic, Offshore	77,532
Western North Atlantic, Northern migratory, coastal	11,548
Western North Atlantic, Southern migratory, coastal	9,173
Western North Atlantic, S. Carolina/Georgia coastal	4,377
Western North Atlantic, Northern Florida coastal	1,219
Western North Atlantic, Central coastal Florida	4,895
Gulf of Mexico Continental shelf	51,192
Gulf of Mexico, Eastern coastal	12,388
Gulf of Mexico, Northern coastal	7,185
Gulf of Mexico, Western coastal	20,161
Gulf of Mexico Oceanic	5,806

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, 1980c; 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 (kHz) 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). Jones and Sayigh (2002) reported geographic variations in behavior and in the rates of vocal production. Whistles and echolocation varied between Southport, North Carolina, the Wilmington-North Carolina Intracoastal Waterway the Wilmington, North Carolina, coastline, and Sarasota, Florida. Dolphins at the Southport site whistled more than the dolphins at the Wilmington site, which whistled more than the dolphins at the Intracoastal Waterway site, which whistled more than the dolphins at the Sarasota site. Echolocation production was higher at the Intracoastal Waterway site than all of the other sites. Dolphins in all three of the North Carolina sites spent more time in large groups than the dolphins at the Sarasota site. Echolocation occurred most often when dolphins were socializing (Jones and Sayigh, 2002).

4.2.20 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; 1,634 to 1,934 in Australian waters; and 136 to 179 dolphins off Zanzibar, Tanzania (Wang and Yang, 2009). The population off Natal numbers 900, while more than 600 dolphins occur in Shark Bay, Australia, 700 to 1,000 at Point Lookout, Australia, 334 in Moreton Bay, Australia, more than 24 off Taiwan, and 44 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).

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). 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).

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. (2005) 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 μs, and peak frequencies that range from 45 to 141 kHz (de Freitas et al., 2015; Wahlberg et al., 2011b).

4.2.21 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. In the ETP, 640,000 Northeastern Pacific Offshore pantropical spotted dolphins have been estimated (Gerrodette and Forcada, 2005); 228,000 in the ETP coastal stock, and 800,000 in the ETP western/southern stock (Jefferson et al., 2015). The Western North and Western South Pacific populations of pantropical spotted dolphins is estimated to included 438,064 individuals, while the portion of the Western North Pacific stock occurring in the South and East China seas is estimated to include fewer members, estimated as 219,032 individuals ((Miyashita, 1993). In the central North Pacific surrounding the Hawaiian Islands, four stocks of pantropical spotted dolphins have been documented: the pelagic stock, estimated as 15,917 dolphins (Bradford et al., 2013; Carretta et al., 2014), as well as the Hawaii Island, Oahu, and 4-Islands stocks, which have each been estimated to include 220 individuals (Courbis et al., 2014). An estimated 3,333 occur in the western North Atlantic and 50,880 dolphins are estimated in the northern Gulf of Mexico (Perrin, 2009b; Waring et al., 2015). 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, 2009b). 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 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, 2009b). 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). Pantropical spotted dolphins off Hawaii have been recorded to dive at 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, 2009b).

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). There are no direct hearing measurements for the pantropical spotted dolphin.

4.2.22 Striped Dolphin (*Stenella coeruleoalba*)

Striped dolphins are a lower risk (least concern) species classified by the IUCN. Striped dolphins are known to be the most abundant marine mammal species in the Mediterranean Sea, with an estimated 117,880 individuals in the Western Mediterranean Sea (Forcada and Hammond, 1998). In the ETP, an estimated 964,362 striped dolphins occur (Gerrodette et al., 2008), and 570,038 individuals are estimated for the Western North and Western South Pacific and Inshore Archipelago stocks (Miyashita, 1993). Off the Pacific coast of the U.S., an estimated 10,908 spinner dolphins are estimated in the California/Oregon/Washington stock while and the Hawaiian EEZ, 20,650 striped dolphins are estimated (Bradford et al., 2013; Carretta et al., 2015). In the western North Atlantic, an estimated 54,807 spinner dolphins are estimated while in the northern Gulf of Mexico, an estimated 1,849 dolphins occur (Waring et al., 2015). Striped dolphins in the Eastern North Atlantic number 67,414 individuals (Hammond et al., 2009). 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 waters. Their full range is unknown, but they are known to range from the Atlantic coast of northern South America up to the eastern seaboard of North America, with a northern limit following the Gulf Stream. They are found in the eastern North Atlantic, south of the United Kingdom, and are the most frequently observed dolphin in the Mediterranean Sea and the Arabian Gulf (Braulik et al., 2010). Striped dolphins have also been documented off the coast of several countries bordering the Indian Ocean. Striped dolphins are found outside the continental shelf, over the continental shelf, and are associated with convergence zones and waters influenced by upwelling. Temperature ranges for these dolphins are reported at 10 to 26°C but most often between 18° and 22°C. In the Ligurian Sea, striped dolphins are commonly found along the Ligurian Sea Front, which has water depths of 6,562 to 8,202 ft (2,000 to 2,500 m). It is believed that they have a high abundance in this area due to a high biological productivity, which attracts and sustains their prey. Striped dolphins may be more active at night because the fish and cephalopods that they eat migrate to the surface at night (Gordon et al., 2000).

Average swim speeds of 5.9 kt (11 kph) were measured from striped dolphins in the Mediterranean (Archer and Perrin, 1999). 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). Dive times are unknown for this species.

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).

4.2.23 Atlantic Spotted Dolphin *(Stenella frontalis)*

The Atlantic spotted dolphin is classified as a data deficient species by the IUCN. The global abundance of the Atlantic spotted dolphin is unknown. In the western North Atlantic, the population estimated for most of the U.S. Atlantic waters (between Florida and Maryland) is 44,715 (Waring et al., 2015), while the number estimated in the northern Gulf of Mexico is 3,200 Atlantic spotted dolphins (Jefferson et al., 2015).

The Atlantic spotted dolphin is found only in the tropical and warm-temperate waters of the Atlantic Ocean. They are commonly found around the southeastern U.S. and the Gulf coasts, in the Caribbean, and off West Africa. They inhabit waters around the continental shelf and the continental shelf-break. Atlantic spotted dolphins are usually near the 656 ft (200 m) depth contour, but they occasionally swim closer to shore in order to feed.

In the Gulf of Mexico, Atlantic spotted dolphins were recorded diving 131 to 197 ft (40 to 60 m) deep (Perrin, 2009c). The average dive time was around 6 min, and most, if not all dives were less than 10 min in duration (Perrin, 2009c).

There are no current hearing data on Atlantic spotted dolphins. Atlantic spotted dolphins produce a variety of sounds, including whistles, whistle-squawks, buzzes, burst-pulses, synch pulses, barks, screams, squawks, tail slaps, and echolocation clicks. Like other odontocetes, they produce broadband, short duration echolocation signals. Most of these signals have a bimodal frequency distribution. They project relatively high-amplitude signals with a maximum SL of about 223 dB (Au and Herzing, 2003). Their broadband clicks have peak frequencies between 60 and 120 kHz. Dolphins produce whistles with a frequency range of 1-23 kHz and with a duration less than one second (Azevedo et al., 2010; Lammers et al., 2003). These whistles often have harmonics which occur at integer multiples of the fundamental and extend beyond the range of human hearing. Atlantic spotted dolphins have also been recorded making burst pulse squeals and squawks, along with bi-modal echolocation clicks with a low-frequency peak between 40 and 50 kHz and a high-frequency peak between 110 and 130 kHz. Many of the vocalizations from Atlantic spotted dolphins have been associated with foraging behavior (Herzing, 1996). There are no available data regarding seasonal variation in the sound production of *Stenella* dolphins, although geographic variation is evident. Peak-to-peak SLs as high as 210 dB have been measured (Au and Herzing, 2003).

4.2.24 Spinner Dolphin (*Stenella longirostris*)

Spinner dolphins are classified overall as a data deficient species by the IUCN, although the eastern population in the ETP is considered vulnerable. Spinner dolphins are one of the most abundant dolphin species in the world. In the ETP, 450,000 Eastern stock spinner dolphins have been estimated (Gerrodette and Forcada, 2005). In the Western North and South Pacific, 1,015,059 spinner dolphins have been estimated (Ferguson and Barlow, 2001 and 2003). In Hawaiian waters, the Hawaii pelagic stock includes 3,351 dolphins (Barlow, 2006), and the island associated populations include the Kaua'i and Ni'ihau stock with 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). In the northern Gulf of Mexico, there are an estimated 11,441 individuals in the stock number and 262 spinner dolphins in the Western North Atlantic (Waring et al., 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).

Hawaiian spinner dolphins have swim speeds ranging from 1.4 to 3.2 kt (2.6 to 6 kph) (Norris et al., 1994). 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).

There are no current hearing data on spinner dolphins. The amount and variety of signal types generally increases with increasing social activity, particularly in Hawaiian spinner dolphins (Frankel, 2009). Spinner dolphins produce burst pulse calls, echolocation clicks, whistles, and screams (Bazua-Duran and Au, 2002; Norris et al., 1994). The results of a study on spotted and spinner dolphins conducted by Lammers et al. (2003) revealed that the whistles and burst pulses of the two species span a broader frequency range than is traditionally reported for delphinids. The fundamental frequency contours of whistles occur in the human hearing range, but the harmonics typically reach 50 kHz and beyond. The whistle contours of near shore spinner dolphins in Hawaiʻi show geographic variation between groups (Bazua-Duran and Au, 2004), correlating with the Island associated populations. Additionally, the burst pulse signals are predominantly ultrasonic, often with little or no energy below 20 kHz (Lammers et al., 2003). Echolocation clicks show the typical delphinid broadband character, with center frequencies ranging from 34 to 58 kHz, peak frequencies from 27 to 41 kHz, and durations of 140 to 620 μs (Baumann-Pickering et al., 2010).

4.2.25 Clymene Dolphin (*Stenella clymene*)

Clymene dolphins are one of the more poorly known dolphin species and are classified as data deficient by the IUCN. Global population estimates are unknown, but there are an estimated 129 in the northern Gulf of Mexico (Waring et al., 2015).

Clymene dolphins are only found in the tropical to warm-temperate waters of the Atlantic Ocean from New Jersey in the northwestern Atlantic Ocean to Brazil and West Africa (Angola) in the South Atlantic Ocean (Jefferson et al., 2015). Most sightings of Clymene dolphins have been in deep, oceanic waters, but they have also been observed close to shore in areas where deep water approaches the coast. Very little is known about their ecology (Jefferson et al., 2015).

There are no measurements for Clymene dolphin hearing abilities. Clymene dolphins generally produce a higher frequency whistle than other *Stenella* species. The Clymene dolphin whistle frequency was measured ranging from 6.3 to 19.2 kHz (Mullin et al., 1994).

4.2.26 Peale's Dolphin (*Lagenorhynchus australis*)

Peale's dolphins are classified at data deficient under the IUCN. Although the only abundance estimate for this species is 200 individuals in southern Chilean waters, the species is considered to be fairly abundant throughout its range (Jefferson et al., 2015). Peale's dolphins inhabit the open coastal waters of Patagonia, Tierra del Fuego, and Chile as well as the deep, protected bays and channels of southern Chile (Goodall, 2009a). Peale's dolphins are routinely observed in the waters of the Falkland Islands (Jefferson et al. 2015). The dive sequences Peale's dolphins are usually three short dives followed by one longer dive with dive durations from 3 to 157 sec, averaging 28 sec (Goodall, 2009a).

Species in this genus produce sounds as low as 0.06 kHz and as high as 325 kHz with dominant frequencies at 0.3 to 5 kHz, 4 to 15 kHz, 6.9 to 19.2 kHz, and 60 to 80 kHz (Popper, 1980c; Schevill and Watkins, 1971). Peale's dolphin vocalizations were recorded in the Chilean channel with broadband clicks at 5 to 12 kHz and narrowband clicks at 1 to 2 kHz bandwidths (Goodall, 2009a). Peale's dolphin SLs were recorded at estimated levels of 80 dB re 1 µPa @ 1 m with a frequency of 1 to 5 kHz and were mostly inaudible at more than 65.6 ft (20 m) away (Schevill and Watkins, 1971).

4.2.27 Dusky Dolphin (*Lagenorhynchus obscurus*)

The dusky dolphin is listed as data deficient species under the IUCN. No global population estimates are available for this species. Dusky dolphins occur off New Zealand, central and southern South America, southwestern and southern Africa, southern Australia, and several islands in the South Atlantic and southern Indian Oceans (Jefferson et al., 2015; Van Waerebeek and Würsig, 2009). Dusky dolphins occur primarily in neritic waters but have been observed in deep waters when it approaches close to continental or island coasts (Van Waerebeek and Würsig, 2009). Although no well-defined seasonal migration patterns are apparent, this species are known to move over a range of 780 km (421 nmi) (Van Waerebeek and Würsig, 2009). Dusky dolphins off Argentina and New Zealand move inshore-offshore on both a diurnal and a seasonal scale. Calving takes place from November to February (Croll et al., 1999).

Off Argentina, the mean dive time for dusky dolphins was 21 sec, with shorter dives during the day and longer dives at night (Würsig, 1982). Dusky dolphins in New Zealand swim at mean routine speeds between 2.4 and 6.6 kt (4.5 and 12.2 kph) (Cipriano, 1992; Würsig and Würsig, 1980). During feeding they can burst at speeds up to 19 kt (36 kph) (Bernasconi et al., 2011).

There are no hearing data available for this species. Dusky dolphins produce bimodal echolocation clicks, with lower frequency clicks from 40 to 50 kHz and high frequency clicks between 80 and 110 kHz (Waerebeek and Würsig, 2009). Au and Würsig (2004) reported echolocation clicks between 30 and 130 kHz, with a maximum SL of 210 dB re 1 µPa @ 1 m. Whistles were also recorded, but only at a rate of 0.01 whistle per minute. Those whistles ranged from 7 to 16 kHz with durations less than once second (Yin, 1999).

4.2.28 Atlantic White-sided Dolphin *(Lagenorhynchus acutus)*

The Atlantic white-sided dolphin is listed as a least concern (lower risk) species under the IUCN. The estimated population in the North Atlantic is 150,000 to 300,000 Atlantic white-sided dolphins (Cipriano, 2009). In the western North Atlantic, there are an estimated 48,819 Atlantic white-sided dolphins (Waring et al., 2015), and the Eastern North Atlantic stock includes an estimated 3,904 dolphins (Hammond et al., 2002). Off the western coast of Scotland, an estimated 96,000 Atlantic white-sided dolphins occur (Jefferson et al., 2015), while in the Labrador Sea stock, 24,422 Atlantic white-sided dolphins have been estimated (Lawson and Gosselin, 2009 and 2011; Waring et al., 2015).

Atlantic white-sided dolphins are found only in the cold-temperate waters of the North Atlantic from about 38°N (south of U.S. Cape Cod) and the Brittany coast of France north to southern Greenland, Iceland, and southern Svalbard (Jefferson et al., 2015). They are generally found in continental shelf and slope waters but are also observed in shallow and oceanic waters. Cape Cod is the southern limit to the Atlantic white-sided dolphin, with an eastern limit of Georges Bank and Brittany. It has been noted that there are seasonal shifts in abundance for the Atlantic white-sided dolphin (Jefferson et al., 2015). Calving occurs during the summer months with peaks in June and July (Croll et al., 1999; Jefferson et al., 2015).

Atlantic white-sided dolphins are probably not deep divers. A tagged dolphin dove for an average of 38.8 sec with 76 percent of the dives lasting less than 1 minute; this dolphin also swam at an average speed of 3.1 kt (5.7 kph) (Mate et al., 1994). The maximum dive time recorded from a tagged animal was 4 min (Cipriano, 2009).

There are no available hearing data on the Atlantic white-sided dolphin. Whistle vocalizations of Atlantic white-sided dolphins have been recorded with a dominant frequency of 6 to 15 kHz (Richardson et al., 1995). The average estimated SL for an Atlantic white-sided dolphin is approximately 154 dB re 1 µPa @ 1 m with a maximum at 164 dB re 1 µPa @ 1 m (Croll et al., 1999).

4.2.29 White beaked Dolphin (*Lagenorhynchus albirostris*)

The white-beaked dolphin is classified as a least concern (lower risk) species under the IUCN. There is no global population estimate for this species. A total of 7,856 white-beaked dolphins are estimated in the North Sea and adjacent waters (Hammond et al., 2002) while 2,003 white-beaked dolphins are estimated in the western North Atlantic (Waring et al., 2015). White-beaked dolphins in the Eastern North Atlantic number 16,536 dolphins (Hammond et al., 2013).

White-beaked dolphins are distributed in the temperate and subarctic North Atlantic Ocean and share a similar habitat to that of the Atlantic white-sided dolphin but with a more northern range (Evans, 1987; Kinze, 2009; Reeves and Leatherwood, 1994). Reports of white-beaked dolphins in the Mediterranean Sea are questionable (Jefferson et al., 2015; Kinze, 2009). This species is distributed principally in continental shelf waters of these four high density areas: Labrador Shelf including southwestern Greenland, Iceland, Scotland/North Sea/Irish Sea, Norway coast to White Sea (Kinze, 2009).

Very little is known about the diving or swimming behavior of white-beaked dolphins. Tagged white-beaked dolphins in Icelandic waters were reported diving to the maximum depth, 148 ft (45 m), which was near the seafloor; exhibited U- and V-shaped dives; dove for durations of 2 to 78 sec; and swam at speeds of 1.9 to 2.7 kt (3.5 to 5 kph) (Rasmussen et al., 2013).

Nachtigall et al. (2008) performed AEP measurements on the white beaked dolphin. An adult male was measured to have a hearing threshold near 100 dB at 152 kHz, and 121 dB at 181 kHz. Clicks produced by white-beaked dolphins resemble those by bottlenose dolphins. They make short, broadband clicks with peak frequencies of about 120 kHz (Rasmussen et al., 2002). They are approximately 10 to 30 msec in duration. Some clicks have a secondary peak of 250 kHz. The maximum sound level was recorded at 219 dB re 1 µPa @ 1 m and was measured at a range of 22 m (72.2 ft) (Rasmussen et al., 2002). Whistles had source levels of 118 to 167 dB (Rasmussen et al., 2006). The fundamental frequency of these whistles ranged from 7 to 13 kHz, and harmonics up to 50 kHz were observed. Burst-pulse sounds have also been described. The peak frequency of these sounds ranged from 1.5 to 46.5 kHz with durations less than 0.6 second (Simard et al., 2008). The maximum recorded source level was 159 dB re 1 µPa @ 1 m.

4.2.30 Hourglass Dolphin (*Lagenorhynchus cruciger*)

Hourglass dolphins are listed as least concern under the IUCN. There is no global population abundance available, but Kasamatsu and Joyce (1995) estimated the abundance of hourglass dolphins south of the Antarctic Convergence as 144,300 dolphins.

Hourglass dolphins are oceanic and occur in the Southern Hemisphere from 45°S to the pack ice or about 60°S in Antarctic and Subantarctic waters that range in temperature from 0.3° to 13.4°C (32.54° to 56.1°F) (Goodall, 2009b) Although an oceanic species, hourglass dolphins have been sighted near islands and over banks and areas where the water is turbulent (Goodall, 2009b). Nothing is known about the migratory movements of this species but they move seasonally into nearshore or Subantarctic waters (Goodall, 2009b).

There are no available hearing data for this species. Tougaard and Kyhn (2010) recently recorded echolocation clicks of hourglass dolphins with frequencies ranging from about 100 to 190 kHz, a mean peak frequency of 125 kHz, and signal duration of 150 msec. The apparent peak-to-peak source level is 190 to 2003 dB (Kyhn et al., 2009).

4.2.31 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). There are an estimated 26,930 Pacific white-sided dolphins in the waters of the U.S. west coast (California/Oregon/Washington stock) and an estimated 26,880 in the Gulf of Alaska (Allen and Angliss, 2015; Carretta et al., 2015). Some animals found in the Gulf of Alaska could also be part of the U.S. west coast stock. In Japanese waters, 30,000 to 50,000 Pacific white-sided dolphins have been estimated to occur (Nishiwaki, 1972).

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 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 low frequency sounds (i.e., 100 Hz to 1 kHz) (Tremel et al., 1998). Pacific white-sided dolphins produce broad-band clicks that are 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.

4.2.32 Rough-toothed Dolphin (*Steno bredanensis*)

The rough-toothed dolphin is classified as least concern by the IUCN. Globally, few population estimates are available for the rough-toothed dolphin except in the ETP, where the stock was estimated at 107,633 individuals (Gerrodette et al., 2008); in the U.S. Atlantic and Gulf of Mexico, where the stocks were estimated as 271 and 624 dolphins, respectively (Waring et al., 2015); and in Hawaiian waters, where the stock was estimated at 6,288 individuals (Carretta et al., 2015). The populations of rough-toothed dolphins in the Western North and South Pacific were estimated to include 145,729 dolphins (Ferguson and Barlow, 2001 and 2003). 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, 2009a). In the Atlantic Ocean, they are found from the southeastern U.S. to southern Brazil and from the Iberian Peninsula and West Africa to the English Channel and North Sea. Their range also includes the Gulf of Mexico, Caribbean Sea, and the Mediterranean Sea (Jefferson, 2009a). In the Pacific, they inhabit waters from central Japan to northern Australia and from Baja California, Mexico, south to Peru. In the eastern Pacific, they are associated with warm, tropical waters that lack major upwelling (Jefferson, 2009a). Their range includes the southern Gulf of California and the South China Sea. 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 are not known to be fast swimmers. They are known to skim the surface at a moderate speed (Jefferson, 2009a). Swim speeds of this species vary from 3.0 to 8.6 kt (5.6 to 16 kph) (Ritter, 2002; Watkins et al., 1987b). 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).

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, 1980b; 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, 1980b). There are no available data regarding seasonal or geographical variation in the sound production of this species.

4.2.33 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). In the U.S. waters of California, Oregon, and Washington, northern right whale dolphins have been estimated as 21,332 dolphins and 8,334 dolphins, respectively, depending upon oceanographic conditions that factored into their distributional extent (Forney et al., 1995; Carretta 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. This species has 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).

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). The maximum recorded dive duration is 6.25 min with a maximum dive depth of 656 ft (200 m) (Fitch and Brownell, 1968; 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).

4.2.34 Southern Right Whale Dolphin *(Lissodelphis peronii)*

The southern right whale dolphin is classified as a data deficient species by the IUCN. The global population estimate for this species is unknown and virtually nothing known regarding the population status of this species.

Southern right whale dolphins only occur in the cold temperate to subantarctic oceans of the Southern Hemisphere between 25° and 65°S; the Antarctic Convergence Zone forms the effective southern limit of this species range (Lipsky, 2009). An oceanic species, the southern right whale dolphin can be found deepwater coastal areas as well (Jefferson et al., 2015). Southern right whale dolphins can swim up to 22 kph (12 kt) and dive as long as 6.5 min (Cruickshank and Brown, 1981). These dolphins appear to make dives to about 200 m (656 ft) while foraging (Fitch and Brownell, 1968). The hearing sensitivity of southern right whale dolphins has not been directly measure nor is any sound production information or data available (Ketten, 2000; Thewissen, 2002). Southern right whale dolphins do not produce whistles (Oswald et al., 2008).

4.2.35 Subfamily Cephalorhynchinae

This group includes the Commerson's dolphin (*Cephalorhynchus commersonii*), Chilean dolphin (*Cephalorhynchus eutropia*), Heaviside's dolphin (*Cephalorhynchus heavisidii*), and Hector's dolphin (*Cephalorhynchus hectori*).

Commerson's and Heaviside's dolphins are classified as data deficient species. Heaviside's dolphin is listed as Near Threatened while the South Island population Hector's dolphin is classified as endangered and the North Island population is critically endangered under the IUCN. The worldwide population size for all species of *Cephalorhynchus* spp. is unknown. The South American population of Commerson's dolphins is estimated as 31,000 individuals (Dawson, 2009), while the Chilean dolphin population is not as well enumerated, with estimates ranging from 59 to several thousand animals (Jefferson et al., 2015; Dawson, 2009). In New Zealand waters, Hector's dolphins are estimated as 111 animals surrounding the North Island with 7,270 animals found around the South Island (Dawson, 2009; Slooten et al., 2002). Only one population estimate of 6,345 animals exists for Heaviside's dolphins in the Cape Town, South Africa region (Elwen et al., 2009).

Cephalorhynchus dolphins are found only in the temperate shallow (<656 ft [<200 m]), coastal waters of the Southern Hemisphere (Dawson, 2009; Goodall, 1994a, 1994b; Goodall et al., 1988; Sekiguchi et al., 1998). In summer, some species are even observed in the surf zone (Dawson, 2009). Commerson's dolphins occur in two distinct populations, one in the Atlantic waters off southern South America (Chile and Argentina), including the Falkland Islands, and the other in the southern Indian Ocean waters off the Kerguelen Islands (Dawson, 2009; Goodall, 1994b). The Chilean dolphin is restricted to the shallow coastal and inshore (estuaries and rivers) waters of Chile from about 33° to 55°S and occurs year-round throughout this range (Jefferson et al. 2015; Dawson, 2009); this species is frequently observed in very close proximity to the shoreline. Hector's dolphins inhabit shallow waters surrounding New Zealand, occurring commonly along the east and west coasts of South Island but with a much smaller population in the waters of the North Island (Slooten and Dawson, 1994). Hector's dolphins are rarely seen more than 4.3 nmi (8 km) from shore or in waters greater than 246 ft (75 m) deep (Jefferson et al., 2015). Heaviside's dolphins are only found along southwestern Africa from Cape Town, South Africa to Namibia (from 17°S to 34°S), typically occurring in shallow water no deeper than 328 ft (100 m) (Jefferson et al., 2015; Dawson, 2009). There is no evidence of large-scale seasonal movement for Heaviside's dolphins (Dawson, 2009).

Commerson's dolphins have been observed swimming at speeds of at least 16 kt (30 kph) (Gewalt, 1990), while Heaviside's dolphins swim much more slowly at a typical speed of 0.9 kt (1.6 kph) and a maximum speed of 2.1 kt (3.8 kph) (Davis, 2010). The average foraging dive of the Hector's dolphin ranges from 1 to 1.5 min (Slooten et al., 2002). Heaviside's dolphins also make shallow dives typically less than 2 min to no more than 66 ft (20 m), although they are capable of diving to 341 ft (104 m) and remaining submerged for up to 10 min (Davis, 2010).

There is no direct measurement of the hearing sensitivity of *Cephalorhynchus* dolphins (Ketten, 2000; Thewissen, 2002). Dolphins of this genus produce sound as low as 320 Hz and as high as 150 kHz (Croll et al., 1999). The vocalizations of this genus have been characterized as narrow-band, high frequency, with energy concentrated around 130 kHz and little to no energy below 100 kHz (Au, 1993; Götz et al., 2010). These narrow-band vocalizations of *Cephalorhynchus* dolphins are relatively low power with a high center frequency (Frankel, 2009). The vocalizations of Commerson's and Hector's dolphins have been studied the most extensively. Members of this genus produce only variations of click and no whistles vocalizations (Frankel, 2009).

The mean peak-to-peak SL for the Commerson's dolphin's vocalizations is 177 dB re 1 µPa @ 1 m (Kyhn et al., 2010). Commerson's dolphins emit varied click vocalizations, and those with a high rate of clicks have been termed "cries" that range up to 5 kHz in frequency with a peak frequency around 1 kHz (Dziedzic and De Bufrenil, 1989). Commerson's dolphins emit three click signal-types that have peak frequencies at 1 to 2.4 kHz, 1.6 to 75 kHz, and 116 kHz (Dziedzic and DeBuffrenil, 1989). Commerson's dolphin produce narrow bandwidth high frequency clicks with a peak frequency of >110 kHz and frequencies ranging from about 110 to ~200 kHz (Kyhn et al., 2010; Yoshida et al., 2014). Hector's dolphin emit sounds that are short (140 msec) with a high peak frequency of 129 kHz (Thorpe and Dawson, 1991). The clicks of Hector's dolphins range from 82 to 135 kHz with a mean peak frequency of 129 kHz and a SL of 177 dB re 1 µPa @ 1 m (Thorpe and Dawson, 1991; Kyhn et al., 2009). Chilean dolphins emit clicks with a peak frequency at 126 kHz and a SL of 177 dB re 1 µPa @ 1 m (Götz et al., 2010). Heaviside's dolphins emit signals that are <2 to 5 kHz with a dominant frequency of 800 Hz (Watkins et al., 1977). Echolocation clicks have a center frequency of 125 kHz, a mean duration of 74 µs and a peak-to-peak source level of 173 dB (Morisaka et al., 2011).

4.2.36 Dall's Porpoise (*Phocoenoides dalli*)

Dall's porpoises are separated taxonomically into two major ecotypes or subspecies: the *truei*-type and the *dalli*-type. 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). In the North Pacific Ocean, there are an estimated 42,000 Dall's porpoises in the California/Oregon/Washington stock (Carretta et al., 2015), and 173,638 porpoises estimated in the Sea of Japan, Western North Pacific, and Alaska stocks (Allen and Angliss, 2015; IWC, 2008). In the Sea of Okhotsk, 111,402 *dalli*-type and 101,173 *truei*-type Dall's porpoises in the Western North Pacific stock are estimated (Kanaji et al., 2015).

The Dall's porpoise is found exclusively in the North Pacific Ocean and adjacent seas (Bering Sea, Okhotsk Sea, and Sea of Japan) (Jefferson et al., 2015). This oceanic species is primarily found in deep offshore waters from 30°N to 62°N or in areas where deepwater occurs close to shore, but this species 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, 2009b).

Dall's porpoises are thought to be one of the fastest swimming of the small cetaceans (Croll et al., 1999; Jefferson, 2009b). Average swim speeds are between 1.3 and 11.7 kt (2.4 and 21.6 kph) and 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). They are relatively deep divers, diving to 900 ft (275 m) for as long as 8 min (Hanson et al., 1998; Ridgway, 1986).

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.

4.2.37 Harbor Porpoise (*Phocoena phocoena*)

Harbor porpoises are classified overall as least concern under IUCN. The global population for the harbor porpoise estimated to be at least 675,000 (Jefferson et al., 2015). Three major residential isolated populations exist: 1) the North Pacific; 2) North Atlantic; and 3) the Black Sea (Jefferson et al., 2008; Bjorge and Tolley, 2009). However, there are morphological and genetic data that suggest that different populations may exist within these three regions (Jefferson et al., 2008). For example, there are 10 different stocks in U.S. waters alone, with nine stocks in the North Pacific, and one in the Gulf of Maine in the North Atlantic (Allen and Angliss, 2015; Caretta et al., 2015; Waring et al., 2015).

In the Gulf of Maine and Bay of Fundy, there are an estimated 79,833 harbor porpoises (Waring et al., 2015) while 3326 individuals are estimated in the Newfoundland stock (Lawson and Gosselin, 2009 and 2011; LGL, 2015; Waring et al., 2015). Harbor porpoise populations have been estimated as 27,000 in the Gulf of Saint Lawrence, 28,000 in Iceland waters, 36,000 in Kattegat, 268,000 in the North Sea, and 36,000 in the waters around Ireland and the western United Kingdom (Jefferson et al., 2015). The Eastern North Atlantic stock is estimated as 375,358 porpoises (Hammond et al., 2013). In Alaska, there are 11,146 porpoises in the southeastern Alaska population, 31,046 individuals in the Gulf of Alaska, and 48,215 harbor porpoises in the Bering Sea (Allen and Angliss, 2015). The Western North Pacific population consists of an estimated 31046 individuals (Allen and Angliss, 2014; Hobbs and Waite, 2010). There are seven populations described off the west coast of the U.S.: the Morrow Bay population with 2,917 individuals; Monterey Bay estimated as 3,715 porpoises; San Francisco to the Russian River includes 9,886 individuals; northern California and southern Oregon there are 35,769 porpoises, while 10,662 individuals are estimated in the Washington inland waters (Carretta et al., 2015).

Harbor porpoises are found in cold temperate and sub-arctic coastal waters of the northern hemisphere (Bjørge and Tolley, 2009; Gaskin, 1992; Jefferson et al., 1993). They are typically found in waters of about 41 to 61° F (5 to 16° C) with only a small percentage appearing in arctic waters 32° to 39° F (0° to 4° C) (Gaskin, 1992). They 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 that may be related to oceanographic changes throughout certain times of the year (Gaskin, 1992; Heimlich-Boarn et al., 1998;

Read and Westgate, 1997). Although migration patterns have been inferred in harbor porpoise, data suggest that seasonal movements of individuals are discrete and not temporally coordinated migrations (Gaskin, 1992; Read and Westgate, 1997).

Maximum swim speeds for harbor porpoises range from 9.0 to 12.0 kt (16.6 and 22.2 kph) (Gaskin et al., 1974). Dive times range between 0.7 and 1.7 min with a maximum dive duration of 9 min (Westgate et al., 1995). The majority of dives range from 65.6 to 426.5 ft (20 to 130 m), although maximum dive depths have reached 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).

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 1-2 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.

4.2.38 Spectacled Porpoise (*Phocoena dioptrica*)

The spectacled porpoise is one of the world’s most poorly known cetaceans. This species is classified as data deficient by the IUCN. There is no information about the abundance of this species (Goodall, 2009c). There are also no data on diving, swim speeds, hearing, or vocalizations.

Spectacled porpoises are circumpolar in occurrence and are found only in the cool temperate, sub-Antarctic, and Antarctic waters of the southern hemisphere (Goodall, 2009c). The species is known from Brazil to Argentina in offshore waters and around offshore islands including Tierra del Fuego, the Falklands (Malvinas), and South Georgia in the southwestern South Atlantic; Auckland and Macquarie in the southwestern Pacific; and Heard and Kergulan in the southern Indian Ocean (Goodall, 2009c). Sightings are most often documented in oceanic waters ranging from 4.9 °to 6.2° C (40.8° to 43° F), but this species has also been sighted in nearshore waters and even in river channels (Goodall, 2009c).

4.3 Pinnipeds

Twenty-nine pinnipeds species may occur in the potential operating areas for SURTASS LFA sonar (Table 5). 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. It is assumed that pinnipeds rely heavily on sound and hearing for breeding activities and social interactions (Berta, 2009; Frankel, 2009; Schusterman, 1978). They are able to hear and produce sounds in both air and water. Pinnipeds have different functional hearing ranges in air and water. Their air-borne vocalizations include grunts, snorts, and barks, which are often used as aggression or warning signals, or to communicate in the context of breeding and rearing young. Under water, pinnipeds can vocalize using whistles, trills, clicks, bleats, chirps, and buzzes as well as lyrical calls (Schusterman, 1978; Berta, 2009; Frankel, 2009). Sensitivity to sounds at frequencies above 1 kHz has been well documented. However, there have been few studies on their sensitivity to low frequency sounds. Various studies have examined the hearing capabilities of some pinniped species, particularly ringed seals, harp seals, harbor seals, California sea lions, and northern fur seals (Kastak and Schusterman, 1996; Kastak and Schusterman, 1998; Møhl, 1968b; Terhune and Ronald, 1972, 1975a, 1975b). Kastak and Schusterman (1998) suggest that the pinniped ear may respond to acoustic pressure rather than particle motion[11] when in the water. Sound intensity level and the measurement of the rate of energy flow in the sound field was used to describe amphibious thresholds in an experiment studying low-frequency hearing in two California sea lions, a harbor seal, and an elephant seal. Results suggest that California sea lions are relatively insensitive to most anthropogenic sound in the water, as sea lions have a higher hearing threshold (116.3 to 119.4 dB RL) at frequencies of 100 Hz than typical anthropogenic noise sources at moderate distances from the source. Harbor seals are approximately 20 dB more sensitive to signals at 100 Hz, compared to California sea lions, and are more likely to hear low-frequency anthropogenic noise. Elephant seals are the most sensitive to low-frequency sound under water with a threshold of 89.9 dB RL at 100 Hz. Kastak and Schusterman (1996 and 1998) also suggest that elephant seals may not habituate well to certain types of sound (in contrast to sea lions and harbor seals), but in fact may become more sensitive to disturbing noises and environmental features associated with the noises.

Past sound experiments have shown some pinniped sensitivity to LF sound. The dominant frequencies of sound produced by hooded seals are below 1,000 Hz (Terhune and Ronald, 1973). Ringed, harbor, and harp seal audiograms show that they can hear frequencies as low as 1 kHz, with the harp seal responding to stimuli as low as 760 Hz. Hearing thresholds of ringed, harbor, and harp seals are relatively flat from 1 to 50 kHz with thresholds between 65 and 85 dB RL (Møhl, 1968a; Terhune, 1991; Terhune and Ronald, 1972, 1975a, 1975b). In a recent study, Kastak et al. (2005) found hearing

11 This is in contrast to fish that are able to detect sound by particle motion.

sensitivity in the California sea lion, harbor seals, and the elephant seal decreased for frequencies below 6.4 kHz (highest frequency tested), but the animals are still able to perceive sounds below 100 Hz.

The California sea lion is one of the few otariid species whose underwater sounds have been well studied. Other otariid species with documented vocalizations are South American sea lions and northern fur seals (Fernández-Juricic et al., 1999; Insley, 2000). Otariid hearing abilities are thought to be intermediate between Hawaiian monk seals and other phocids, with a cutoff in hearing sensitivity at the high frequency end between 36 and 40 kHz. Underwater low frequency sensitivity is between approximately 100 Hz and 1 kHz. The underwater hearing of fur seals is most sensitive with detection thresholds of approximately 60 dB RL at frequencies between 4 and 28 kHz (Babushina et al., 1991; Moore and Schusterman, 1987).

Phocid seals probably hear sounds underwater at frequencies up to about 60 kHz. Above 60 kHz, their hearing is poor. Richardson et al. (1995) indicate that phocids have flat underwater audiograms for mid and high frequencies (1 to 30 kHz and 30 to 50 kHz) with a threshold between 60 and 85 dB RL (Møhl, 1968a; Terhune, 1989, 1991; Terhune and Ronald, 1972, 1975a, 1975b; Terhune and Turnbull, 1995). As mentioned, the elephant seals are the most sensitive to underwater low-frequency sound with a threshold of 89.9 dB RL at 100 Hz (Kastak and Schusterman, 1998).

The sounds produced by pinnipeds vary across a range of frequencies, sound types, and sound levels. The seasonal and geographic variation in distribution and mating behaviors among pinniped species may also factor into the diversity of pinniped vocalizations. The function of sound production appears to be socially important as they are often produced during the breeding season (Kastak and Schusterman, 1998; Van Parijs and Kovacs, 2002).

4.3.1 Otariids

4.3.1.1 South American Fur Seal (*Arctocephalus australis*)

There are two currently recognized sub-species: the Peruvian fur seal, found from Peru to northern Chile with an estimated population size of 12,000, and the South American fur seal, found from southern Chile to the Straits of Magellan and northward to southern Brazil as well as the Falkland Islands, with an estimated Chilean population of 30,000 seals and 15,000 to 20,000 seals estimated in the Falklands. Along the east coast of South America, 250,000 to 300,000 Southern fur seals occur, with most occurring in Uruguay (Jefferson et al., 2015). The South American fur seal is listed as a least concern (lower risk) species under the IUCN.

Most colonies of South American fur seals are located on offshore islands except in Peru, where the colonies are located on the mainland (Arnould, 2009). Males are sometimes seen seasonally up to 324 nmi (600 km) offshore (Jefferson et al., 2015). These fur seals are believed to occur predominantly in continental shelf and continental slope waters.

South American fur seals have been recorded diving to mean water depths of 112 ft (34 m) and a maximum depth of 558 ft (170 m) with mean and maximum dive durations of 2.5 and 7.1 min, respectively (Riedman, 1990). Thompson et al. (2003) found that satellite tagged South American fur seals foraged in waters 50 to about 600 m deep and swam at an average speed of 2.9 kt (1.5 m/sec).

There is no direct measurement of hearing sensitivity for the South American fur seal. The primary airborne calls made by South American fur seals include whimpers, barks, growls, whines, and moans, and a strong vocal connection between mother and pups. The female South American fur seal emits a call with a frequency between 1 and 5,870 Hz, while pups have a higher frequency call, between 1 and 6,080 Hz (Phillips and Stirling, 2000). No descriptions of underwater vocalizations are available.

4.3.1.2 New Zealand Fur Seal (*Arctocephalus forsteri*)

The New Zealand fur seal is listed as a least concern (lower risk) species under the IUCN. The global population estimate is 200,000 to 220,000 seals, split evenly between New Zealand and Australia (Jefferson et al., 2015). The New Zealand fur seal is a temperate species having two genetically distinct populations. One population is around both the North and South islands of New Zealand, with the larger population around South Island. The second population is found on the coast of southern and western Australia (Jefferson et al., 2015). Their principal breeding colonies occur along the coast of South and Stewart Islands of New Zealand as well as along the coast of western and southern Australia, including off Tasmania at Maatsuyker Island (Arnould, 2009). Breeding colonies also exist at the Subantarctic Chatham, Campbell, Antipodes, Bounty, Aukland, and Macquarie islands (Arnould, 2009). The New Zealand fur seal prefers rocky and windy habitats that are protected from the sun for breeding (Jefferson et al., 2015).

New Zealand fur seals forage at night, with varying dive depths and times depending on age and sex. New Zealand fur seal pups were recorded at a maximum dive depth of 144 ft (44 m) for 3.3 min (Baylis et al., 2005). Adult females recorded a maximum dive depth of 1,024 ft (312 m), and a maximum dive time of 9.3 min off the southern coast of Australia (Page et al., 2005). Adult male New Zealand fur seals had a maximum dive of more than 1,247 ft (380 m), and a maximum dive time of 14.8 min (Page et al., 2005). Swim speeds for New Zealand fur seals have been estimated to be similar to congeneric Antarctic fur seals (Harcourt et al., 2002).

In-air vocalizations of the New Zealand fur seal have been described as full-threat calls. These individually distinctive vocalizations are emitted by males during the breeding season (Stirling, 1971). New Zealand fur seals also produce barks, whimpers, growls, whines, and moans (Page et al., 2002). The hearing capabilities of this species are unknown, and no information exists on the frequency range of this species' vocalizations.

4.3.1.3 Galapagos Fur Seal (*Arctocephalus galapagoensis*)

The Galapagos fur seal is listed as endangered under the IUCN. The population is estimated currently as 10,000 to 15,000 individuals (Jefferson et al., 2015).

Galapagos fur seals are non-migratory. Their distributional range is limited to the equatorial region throughout the Galapagos Islands (Arnould, 2009). These seals haul out on rock shorelines with most colonies located in the western and northern parts of the Galapagos Archipelago and occasionally come ashore on the mainland Ecuadorian coast (Jefferson et al., 2015).

The diving habits of Galapagos fur seals are dependent on age. Six-month-old seals have been recorded to dive up to 20 ft (6 m) for 50 sec. Yearlings dive to 150 ft (47 m) for 2.5 min, and 18-month-old juveniles dive up to 200 ft (61 m) for 3 min (Stewart, 2009). The longest and deepest dive recorded by a Galapagos fur seal was 5 min at a depth of 377 ft (115 m) (Jefferson et al., 2015). Galapagos fur seals swim at about 3.1 kt (1.6 m/sec) (Williams, 2009). No information is available on the hearing abilities of this species. Galapagos fur seals produce low frequency long growls (<1 kHz) and short broadband grunts that are less than 2 kHz (Frankel, 2009).

4.3.1.4 Juan Fernandez Fur Seal (*Arctocephalus philippii)*

The Juan Fernandez fur seal is classified as near threatened under the IUCN. The species was believed to have been hunted to extinction until 1965 when a small remnant population was located. Juan Fernandez fur seals are restricted to the Juan Fernandez island group off the coast of north central Chile (Jefferson et al., 2015) and is estimated to number 12,000 individuals (Jefferson et al., 2015). Currently this seal occupies four major breeding colonies and hauls out on rocky shorelines (Arnould, 2009).

Juan Fernandez fur seals can travel an average distance of 353 nmi (653 km) from breeding grounds to feeding grounds, where they forage at depths between 35 and 295 ft (10 and 90 m) (Jefferson et al., 2015). Maximum dive depths for this seal range from 163 to 295 ft (50 to 90 m), with most dives less than 33 ft (10 m) (Francis et al., 1998). The most common dive times lasted less than 1 min, with a maximum dive time of 6 min (Jefferson et al., 2008). Most dives occur at night (Francis et al., 1998). No swim speed information is available.

No information is available on the hearing abilities of the Juan Fernandez fur seal. The Juan Fernandez fur seal has been recorded producing downswept pulses from 200 to 50 Hz (Norris and Watkins, 1971). Other information about this species' sound production capabilities is not available.

4.3.1.5 South African or Cape Fur Seal (*Arctocephalus pusillus pusillus*)

South African or Cape fur seals are one of two *Arctocephalus pusillus* sub-species that are separated by an ocean. South African fur seals are listed as a species of least concern (lower risk) by the IUCN. Censuses in 2004 indicate that the population of South African fur seals is stable at an estimated 2 million animals, with about two-thirds of the population occurring in Namibia (Hofmeyr, 2015; Jefferson et al., 2015). South African fur seals bred at some 40 colonies or colony groups in 2009 (Hofmeyr, 2015). Kirkman et al. (2013) reported an increase in the number of colonies, a northward shift in the range, and an increase in abundance in some areas of the South African fur seal's range (northern Namibia and northwestern South Africa).

South African fur seals occur along the southern and southwestern African coast from southern Angola, Namibia, to eastern South Africa (Jefferson et al., 2015). Breeding occurs at 25 colonies along the coasts of South Africa and Namibia, including four mainland colonies (Arnould, 2009). These fur seals are not migratory, spend most of their year at sea, but don't range far from land, typically feeding within approximately 2.7 nmi (5 km) of land and traveling no more than a maximum of 86 nmi (160 km) from land (King, 1983).

The majority of recorded dives of Cape fur seals on the west coast of South Africa are to less than 164 ft (50 m) of water depth (Kooyman and Gentry, 1986), while those on the southeast coast are to more than 197 ft (60 m) with dives typically lasting from 1 to 2.1 min (Stewardson, 2001). The maximum dive depth and duration are 669 ft (204 m) and 8.9 min (Arnould and Hindell, 2001; Kooyman and Gentry, 1986). Cape fur seal dives show two peaks in the daily distribution with most dives taking place at dusk or during the first half of the night, with a smaller peak after dawn (Kooyman and Gentry, 1986; Stewardson, 2001). No swim speed data are available for this species.

There is also no information available on the hearing abilities of the South African fur seal. South African fur seals make "pup calls" and males make exhibit threat and mating calls during breeding season.

4.3.1.6 Australian Fur Seal (*Arctocephalus pusillus doriferus*)

Australian fur seals are listed as a species of least concern (lower risk) by the IUCN. Most of their breeding and haulout sites are protected by Australian federal, state, and territorial laws. Currently, the population of Australian fur seals is estimated at 110,000 to 120,000 animals (Jefferson et al. 2015).

Australian fur seals are believed to be non-migratory. They are found along the southern and southwestern coast of Australia from just east of Kangaroo Island to Houtman Albrolhos in Western Australia (Jefferson et al., 2015). Breeding colonies are restricted to 10 islands in Bass Strait (Arnould, 2009). Australian fur seals prefer rocky habitats for hauling out and breeding (Jefferson et al., 2015).

Australian fur seals forage at shallow depths along the continental shelf and continental slope waters (Kirkwood et al., 2006). An average dive depth and duration of a male off the coast of Australia was 46 ft (14 m) and 2.3 min; the maximum dive depth and duration that were recorded was 335 ft (102 m) and 6.8 min (Hindell and Pemberton, 1997). No swim speed data are available for this species.

There is no information available on the hearing abilities for the Australian fur seal. Vocalizations made by Australian fur seals are not well known. These fur seals produce a variety of sounds such as barks, mother-pup calls, growls, and submissive calls. Tripovich et al. (2008) found that pups had a maximum energy of 1,300 Hz, while yearlings had a maximum energy of 800 Hz. Females had an average call frequency of 262 ± 35 Hz (Tripovich et al., 2008).

4.3.1.7 Guadalupe Fur Seal (*Arctocephalus townsendi*)

The Guadalupe fur seal is currently classified as threatened under ESA and considered a near-threatened species under IUCN. The current worldwide population size for this species is unknown. In 1993, 7,408 seals were estimated, which remains the most recent population estimate of Guadalupe fur seals available (Caretta et al., 2016).

The distribution of Guadalupe fur seals is centered on Guadalupe Island, Mexico with most breeding occurring there, but recently pups have been born at a former rookery in the San Benitos Islands, Mexico and on San Miguel Island, California (Jefferson et al., 2015). Guadalupe fur seals have been observed as far north as Blind Beach, CA and as far south as Zihuatanejo, Mexico and the Gulf of California (Carretta et al., 2016). These seals prefer either a rocky habitat or volcanic caves.

The Guadalupe fur seal has been recorded swimming from 3.4 to 3.9 kt (1.8 to 2.0 m/sec) (Gallo-Reynoso, 1994). Guadalupe fur seals are shallow divers, foraging within the upper 100 ft (30 m) of the water column and diving to a mean water depth of 56 ft (16.9 m) for mean a duration of 2.6 min (Gallo-Reynoso, 1994).

No direct measurements of auditory threshold for the hearing sensitivity of Guadalupe fur seals are available (Thewissen, 2002). Male Guadalupe fur seals produce airborne territorial calls during the breeding season, including a bark (Pierson, 1987). When disturbed by humans, Guadalupe fur seals have been reported to produce roar type of calls and females produce specific prolonged "bawls" when interacting with their pups (Belcher and Lee, 2002).

4.3.1.8 Subantarctic Fur Seal (*Arctocephalus tropicalis*)

Subantarctic fur seals are considered a least concern (lower risk) species under the IUCN. The current population of this widely dispersed fur seal is more than 310,000 animals (Jefferson et al. 2015). More than 200,000 seals occur at Gough Island in the South Atlantic with good sized colonies occurring in the southern Indian Ocean at Prince Edward Island with 75,000 animals and Amsterdam Island with 50,000 (Arnould, 2009).

This fur seal species ranges throughout the southern hemisphere from the Antarctic Polar Front northward to southern Africa, Australia, Madagascar, and the South Island of New Zealand with rare vagrants reported from as far north as Brazil (Jefferson et al., 2015). Breeding occurs north of the Antarctic Convergence in the South Atlantic and Indian Oceans, mostly on the islands of Amsterdam, Saint Paul, Crozet, Gough, Marion, Prince Edward, and Macquarie (Jefferson et al., 2015).

In the summer, subantarctic fur seals commonly dive to water depths averaging 54.5 to 62 ft (16.6 to 19 m) for 1 min, while dives in the winter seals dive to an average depth of 29 m for 1.5 min; maximum dive depths and durations have been recorded at 682 ft (208 m) and 6.5 min (Jefferson et al., 2015). No swim speed data are available. No information or data are available on subantarctic fur seal hearing or vocalization capabilities.

4.3.1.9 Northern Fur Seal (*Callorhinus ursinus*)

Northern fur seals are currently classified as a vulnerable species under IUCN and depleted under the MMPA. No current global population estimate is available for this species. The Eastern Pacific stock is estimated as 648,534 seals (Allen and Angliss, 2015), while the California (San Miguel Island and the Farallon Islands) stock is estimated to include 14,050 seals (Carretta et al., 2016), and the Western Pacific stock of northern fur seals is estimated as 503,609 individuals (Gelatt et al., 2015; Kuzin, 2014).

Northern fur seals are widely distributed across the North Pacific, and are generally associated with the continental shelf break. They range from northern Baja California, north to the Bering Sea, and across the Pacific to the Sea of Okhotsk and the Sea of Japan (Jefferson et al., 2015). Breeding sites include the Commander Islands, Kurile Islands, Pribilof Islands, Robben Island, Bogoslof Island, Farallon Islands, and San Miguel Island (Gentry, 2009b). Pups leave land after about four months and must learn to hunt while migrating. The migration routes and distribution of pups is difficult to assess because they are small and difficult to recapture, but a known migration route exists through the Aleutian passes into the Pacific Ocean in November (Gentry, 2009b).

Routine swim speeds during migration for this species are 1.54 kt (2.85 kph), and during foraging, swim speeds averaged between 0.48 to 1.23 kt (0.89 and 2.28 kph) (Ream et al., 2005). Maximum recorded dive depths of breeding females are 680 ft (207 m) in the Bering Sea and 755 ft (230 m) off southern California (Goebel, 1998). The average dive duration is near 2.6 min. Juvenile fur seals in the Bering Sea had an average dive time of 1.24±0.09 min, and an average depth of 57.4 ft (17.5 m) (Sterling and Ream, 2004) with a maximum depth of 328 ft (100 m) (Lee et al., 2014).

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, 2009b). Northern fur seals are known to produce clicks and high-frequency sounds under water (Frankel, 2009). Estimated source levels and frequency ranges are unknown.

4.3.1.10 Eastern (Loughlin's) (*Eumetopias jubatus monteriensis*) and 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, 2016). The species is classified as an endangered species under IUCN. Only the Western stock/DPS is listed as endangered under the ESA, while the

Eastern stock/DPS was delisted under the ESA in 2013. All Steller sea lions are considered depleted under the MMPA. The worldwide population size for this species is estimated to be 160,867 (Gelatt and Sweeney, 2016). The Eastern U.S. stock (east of Cape Suckling, Alaska) of Steller sea lions is estimated at between 60,131 and 74,448 individuals, while the Western U.S. stock (west of Cape Suckling, Alaska) is estimated at 49,497 sea lions (Muto et al., 2016). The Steller sea lion population in the Western U.S. and Russian stocks has been estimated to include 82,516 individuals (Allen and Angliss, 2015), while the Western Asian stock (Russia to Japan) has been estimated as 68,218 individuals (Muto et al., 2016).

Steller sea lions are found in temperate or sub-polar waters and are widely distributed throughout the North Pacific from Japan to central California, and in the southern Bering Sea. Breeding generally occurs during May through June in California, Alaska, and British Columbia. The northernmost rookery is found at Seal Rocks in Prince William Sound, Alaska, and the southernmost rookery is found at Año Nuevo Island in California (Loughlin, 2009). They may haul out on sea ice in the Bering Sea and the Sea of Okhotsk, which is unusual for otariids.

Female Steller sea lions on foraging trips during the breeding season had a maximum dive depth of 774 ft (236 m), while the longest dive was greater than 16 min. The average dive depth for foraging females was 97.1 ft (29.6 m). Average dive time was recorded at 1.8 min (Rehberg et al., 2009). 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).

Kastelein et al. (2005) studied the differences between male and female Steller sea lion hearing and vocalizations; female and pup in-air vocalizations are described as bellows and bleats while underwater vocalizations are described as belches, barks, and clicks. Their study was conducted because Steller sea lion hearing may not resemble that of other tested otariids and because there are large size differences between males and females which mean there could be differences in the size structure of hearing organs and therefore differences in hearing sensitivities. The underwater audiogram of the male showed his maximum hearing sensitivity at 77 dB RL at 1 kHz, while the range of his best hearing, at 10 dB from the maximum sensitivity, was between 1 and 16 kHz and the average pre-stimulus responses occurred at low frequency signals (Kastelein et al., 2005). Female Steller sea lions maximum hearing sensitivity, at 73 dB RL, occurred at 25 kHz (Kastelein et al., 2005). The frequency range of underwater vocalizations was not shown and properly studied in this case because the equipment used could only record sounds audible up to 20 kHz. However, the maximum underwater hearing threshold from this study overlaps with the frequency range of the underwater vocalizations that were able to be recorded, and it was stated by the authors that the Steller sea lions in this study showed signs that they can hear the social calls of the killer whale (*Orcinus orca*), one of their main predators. The killer whale's echolocations clicks are between 500 Hz and 35 kHz, which is partially in the auditory range of the Steller sea lions in this study.

Steller sea lion underwater sounds have been described as clicks and growls (Frankel, 2009; Poulter, 1968). Males produce a low frequency roar when courting females or when signaling threats to other males. Females vocalize when communicating with pups and with other sea lions. Pups make a bleating cry and their voices deepen with age (Loughlin, 2009). No available data exist on seasonal or geographical variation in the sound production of this species.

4.3.1.11 California Sea Lion (*Zalophus californianus*)

California sea lions are listed as a least concern (lower risk) species under the IUCN. The population size of the U.S. stock, or Pacific Temperate stock, is estimated as 296,750 seals (Carretta et al., 2015).

California sea lions are common along the Pacific coast of the U.S. and Mexico, ranging from the Tres Marias Islands, Mexico, to the Gulf of Alaska, although California sea lions are rare farther north than Vancouver, British Columbia (Heath and Perrin, 2009; Jefferson et al., 2015). The U.S. stock includes rookeries within the U.S. but the population ranges into Canada (Carretta et al., 2016). The principal breeding areas for the California sea lion are the Channel Islands off southern California, the islands off the coast of Baja California, Mexico, and in the Gulf of California (Heath and Perrin, 2009).

Lactating females have recorded dives to 810 ft (247 m) and lasting over 10 min. Foraging California sea lions had a mean dive time of four minutes, with a maximum time of 10 minutes. Mean dive depth was 453 ft (138 m) with a deepest dive of 1,378 ft (420 m) (McDonald and Ponganis, 2014). Swim speeds for California sea lions have been estimated at 4.9 kt (9 kph) (Feldkamp et al.,1989).

California sea lions can hear sounds in the range of 75 Hz to 64 kHz. Low frequency amphibious hearing tests suggest that California sea lions are relatively insensitive to most anthropogenic sound in the water, as sea lions have a higher threshold (116.3 to 119.4 dB RL) at frequencies of 100 Hz (Kastak and Schusterman, 1998; Mulsow et al., 2012). However, their hearing abilities when presented with complex stimuli (as opposed to pure tones) are 33 dB better than expected based on energetic calculations (Cunningham et al., 2014). Underwater sounds produced by California sea lions include barks, clicks, buzzes, and whinnies. Barks are less than 8 kHz with dominant frequencies below 3.5 kHz; the whinny call is typically between 1 and 3 kHz, and the clicks have dominant frequencies between 500 Hz and 4 kHz (Schusterman, 1966). Buzzing sounds are generally from less than 1 kHz to 4 kHz, with the dominant frequencies occurring below 1 kHz (Schusterman, 1966).

4.3.1.12 Galapagos sea Lion (*Zalophus wollebaeki*)

Galapagos sea lions are classified as endangered under IUCN. The current population is estimated to be between 10,000 and 15,000 seals (Jefferson et al., 2015). Galapagos sea lions are an equatorial species closely related to California sea lions. Their range is restricted to the Galapagos Islands with a small colony on La Plata Island off the coast of Ecuador. Occasionally, vagrants can be seen along the Ecuador and Columbia coasts, particularly around Isla del Coco, Costa Rica, and Isla del Gorgona (Heath and Perrin, 2009).

Galapagos sea lions are a non-migratory species that forage within a few kilometers of the coast, feeding during both the day and night. Their dives average 301.2 ± 115.5 ft (91.8 ± 35.2 m) but have been known to reach as deep as 489 ft (149 m). Average dive duration is 4.0 ± 0.9 min (Villegas-Amtmann et al., 2008). Swim speeds are typically about 3.9 kt (2 m/sec) (Williams, 2009). There is no information available on the hearing abilities or sound production of this species.

4.3.1.13 Australian Sea Lion (*Neophoca cinerea*)

The Australian sea lion is listed as endangered under the IUCN due to its small, genetically fragmented population, which appears to be declining at some colonies. Additionally, most major colonies are at risk of extinction from fishery bycatch. The Seal Bay area has been designated as a conservation park for these sea lions (Ling, 2009). The total population of Australian sea lions has most recently been estimated as 14,780 animals (Jefferson et al. 2015).

The Australian sea lion is a temperate species found only along the south and west coast of Australia (Jefferson et al., 2015). About 73 colonies exist, with 47 colonies documented in southern Australia and 26 reported in Western Australia, although only six colonies produce are large enough to produce more than 100 pups per season (Ling, 2009). The largest breeding colonies are located on Purdie Islands, Dangerous Reef, Seal Bay, and The Pages (Ling, 2009).

Females and juveniles do not typically migrate. Australian sea lions are fast, powerful swimmers (Ling, 2009). Female Australian sea lions dive to an average depth and duration of 138 to 272 ft (42 to 83 m) and 2.2 to 4.1 min, with maximum dives ranging from 197 to 345 ft (60 to 105 m) (Jefferson et al., 2015). The average duration of all foraging dives was 3.3 min, with a maximum dive time of 8.3 min (Costa and Gales, 2003). No information is available on the hearing abilities of this species. Australian sea lions bark and produce clicks under water (Poulter, 1968).

4.3.1.14 New Zealand Sea Lion (*Phocarctos hookeri*)

The New Zealand sea lion, also known as Hooker's sea lion, is listed under the IUCN as vulnerable. This sea lion has an estimated abundance of <10,000 individuals (Jefferson et al. 2015).

This rarely occurring sea lion is endemic to New Zealand waters and has one of the most restricted ranges of all pinnipeds (Gales, 2009). This sea lion occur in two geographically isolated and genetically distinct populations around New Zealand and southern and western coast of Australia (Jefferson et al., 2008). Although once found in all the New Zealand waters, the current breeding range of the New Zealand sea lion is limited to two groups of Subantarctic islands, the Auckland and Campbell Islands, with pups occasionally born along the shore of the South Island; approximately 86 percent of New Zealand sea lion pups are born in the Auckland Islands (Gales, 2009).

New Zealand sea lions are among the deepest and longest divers of the otariids, diving to a mean water depth of 404 ft (123 m), with average dive durations of 3.9 min (Gales, 2009). The maximum foraging dive depth recorded for a lactating female was reported as 1,804 ft (550 m) and the longest dive time was 11.5 min (Costa and Gales, 2000). Swim speeds are about 2.5 kt (4.7 kph) (Williams, 2009) and from 3.1 to 4.7 kt (5.8 to 8.6 kph while diving and from 1.7 to 3.5 kt (3.2 to 6.5 kph) while surface swimming (Crocker et al., 2001).

No information is available on the hearing abilities of this species and little information is available on the vocalizations of New Zealand sea lions except that all bark and produce clicks under water (Poulter, 1968).

4.3.1.15 South American Sea Lion (*Otaria byronia*)

South American sea lions are listed as a least concern (lower risk) species under the IUCN. The current total population is estimated to be between 200,000 and 300,000 seals (Jefferson et al., 2015), with 110,000 sea lions occurring along the southwestern Atlantic coastal areas (Cappozzo and Perrin, 2009).

South American sea lions are nearly continuously distributed along most of South America from southern Brazil to northern Peru, including the Falkland Islands and Tierra del Fuego (Jefferson et al., 2008). This sea lion is principally concentrated in central and southern Patagonia, where more than 53 breeding colonies are found (Cappozzo and Perrin, 2009). The South American sea lion is primarily found in continental shelf and continental slope waters (Jefferson et al., 2015).

Campagna et al. (2001) found the dives of South American sea lions to be short, typically less than 4 min, and shallow, from 6.6 to 98 ft (2 to 30 m). The maximum depth to which a South American sea lion has been recorded diving is 574 ft (175 m) and the maximum dive duration of 7.7 min (Werner and Campagna, 1995). Median swim speed recorded for this species was 1.46 kt (2.7 kph) (Campagna et al., 2001).

No information is available on the hearing abilities of the South American sea lion. South American sea lions produce most vocalizations during their breeding season, with airborne calls by males characterized as high-pitched, directional calls, barks, growls, and grunts while females exhibited grunts and specific calls with their pups that were long duration and harmonically rich (Ferńandez-Juricic et al., 1999). Frequencies of the measured South American sea lion vocalizations ranged widely from 240 to 2,240 Hz (Fernández-Juricic et al., 1999).

4.3.2 PHOCIDS

4.3.2.1 Mediterranean Monk Seal (*Monachus monachus)*

Mediterranean monk seals are listed as endangered under the ESA, classified as critically endangered under IUCN, and protected under CITES. The worldwide population size for this species is estimated to be between 500 and 600 animals (Jefferson et al., 2015), with the largest population of 250 to 300 seals found in the eastern Mediterranean (Gilmartin and Forcada, 2009). One hundred seals are thought to remain in Turkey (Jefferson et al. 2015), and they have been sighted there recently (Emek Inanmaz et al., 2014). The two breeding populations at Cap Blanc, with about 220 seals (Karamanlidis et al., 2015), and in the Desertas Islands of the Madeira Islands group, with about 25 seals, remain (Gilmartin and Forcada, 2009).

Although severely contracted from its former range, Mediterranean monk seals are currently distributed throughout the Mediterranean, Black, Ionian, and Aegean seas and the Sea of Marmara, and in the eastern North Atlantic Ocean from the Strait of Gibraltar south to Mauritania and the Madeira Island (Gilmartin and Forcada, 2009; Jefferson et al., 2008). There is no evidence of seasonal movement for this species. Mediterranean monk seals exhibit high site fidelity and thus only occupy part of their suitable range and habitat (Gilmartin and Forcada, 2009). A monk seal was recently found off Libya. It is not known if this was an extralimital sighting or evidence of another colony (Alfaghi, 2013).

No direct data are available on swim speed for Mediterranean monk seals. Dendrinos et al. (2007) reported a maximum water depth of 404 ft (123 m) for a rehabilitated monk seal that was tagged and released in the Mediterranean Sea. Gazo and Aguilar (2005), however, described the maximum dive depth and duration as 256 ft (78 m) and 15 min while the mean dive depth and duration of the dives of a lactating female were 98 ft (30 m) and 5 min (Gazo and Aguilar, 2005). Kiraç et al. (2002) recorded mean dive durations of 6.4 min for adults and 6.8 min for juveniles.

Although no data are available on underwater hearing or vocalizations of Mediterranean monk seals, some limited data are available for in-air vocalizations of Hawaiian monk seals. Recorded in-air vocalizations of Hawaiian monk seals consist of what has been referred to as 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 Hawaiian Monk Seal (*Monachus schauinslandi*)

Hawaiian monk seals are listed as endangered under the ESA, classified as endangered under IUCN, and protected under CITES. Critical habitat for the Hawaiian monk seal has been established from the shore to 121 ft (37 m) of water depth in 10 areas of the Northwest Hawaiian Islands (NWHI) (NOAA, 1988). In 2015, revisions to the Hawaiian monk seal's critical habitat were established (NOAA, 2015a). The critical habitat now includes all of Kure Atoll, Midway Islands, Pearl and Hermes Reef, Lisianski Island, Laysan

Island, Maro Reef, Gardner Pinnacles, French Frigate Shoals, Necker Island, Nihoa, Kaula Island and Niihau and Lehua Islands to the 628-ft (200-m) isobath It also includes selected portions of the remaining main Hawaiian Islands and all waters to the 200 m isobath (excluding National Security Exclusion zones off Kauai, Oahu and Kahoolawe) (NOAA, 2015a). The best available population estimate for this species is 1,112 individuals (Carretta et al., 2016).

Hawaiian monk seals range throughout the Hawaiian Archipelago and Johnson Atoll (NOAA, 2011). Since the early 1990s, a small but increasing population of monk seals and an increasing number of annual births has been documented in the Main Hawaiian Islands (NOAA, 2011). Hawaiian monk seals exhibit high site fidelity to their natal island (Gilmartin and Forcada, 2009). Monk seals spend a greater proportion of their time at sea, in water depths ranging from 3 to 984 ft (1 to 300 m) in shelf, slope, and bank habitats but come ashore (haul out) on a variety of substrates, including sandy beaches, rocky shores, rock ledges, and emergent reefs. Pupping only occurs on sandy beaches adjacent to protected waters.

Sparse swim speed data are available. Parrish and Abernathy (2006) reported Hawaiian monk seals swimming with a velocity of 3.9 kt (7.2 kph). This species commonly dive to depths of less than 328 ft (100 m) but have been recorded diving down to depths of 984 to 1,640 ft (300 to 500 m) (Parrish et al., 2002). 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 principally shallow water depths from 33 to 131 ft (10 to 40 m) (Stewart, 2009).

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).

4.3.2.3 Northern Elephant Seal (*Mirounga angustirostris)* and Southern Elephant Seal *(M. leonina)*

The total population estimate for the northern elephant seal is over 171,000 (Jefferson et al., 2015). The population estimate for the California breeding stock of this species is 179,000 (Carretta et al., 2015). The population of southern elephant seals has been estimated at 650,000 seals (Jefferson et al., 2015). Two major populations of southern elephant seals are experiencing a decline while northern elephant seals are increasing in number.

Northern elephant seals occur throughout the northeast north-central Pacific Ocean (Jefferson et al., 2015). They occur during the breeding season from central Baja, Mexico to central California in about 15 colonies (Le Boeuf and Laws, 1994; Stewart and DeLong, 1994). Most of the colonies are located on offshore islands. Northern elephant seals make long, seasonal migrations between foraging and breeding areas, with some individuals making two return trips per year, returning to their southern breeding grounds to molt (Hindell and Perrin, 2009). Northern elephant seals are frequently observed along the coasts of Oregon, Washington, and British Columbia and may reach as far north as the Gulf of Alaska and the Aleutian Islands during foraging bouts (Le Boeuf and Laws, 1994). Southern elephant seals have a large range and occur on colonies around the Antarctic Convergence, between 40° and 62°S (King and Bryden, 1981; Laws, 1994). Breeding takes place near the sub-Antarctic zone and sometimes a pup is born on the Antarctic mainland. Southern elephant seals range throughout the Southern Ocean from the Antarctic Polar Front to the pack ice. During non-breeding seasons, both the southern and the northern elephant seals are widely dispersed (Hindell and Perrin, 2009).

Elephant seals spend as much as 90 percent of their time submerged and are remarkable divers, diving to depths (>4,921 ft (>1,500 m) for 120 min (Le Boeuf and Laws, 1994; Hindell and Perrin, 2009). In a study by Davis et al. (2001), an average elephant seal dive duration was recorded as 14.9 min to a maximum dive depth of 289 m (948 ft); average swimming speed was recorded as 2.1 kt (1.1 m/sec). Le Boeuf et al. (1989) reported that northern elephant seals dive to average depths of 1,640 to 2,297 ft (500 to 700 m) with most dives lasting 17 to 22.5 min with the longest dive duration as 62 min. Continuous deep dives are the normal state for these pelagic, deep divers. Dive depths and durations differ between adult male and females depending on the season and geographic location (Stewart, 2009). Elephant seals have multiple different dive types. There are six generally recognized: A, B, C, D E_b, E_f (Dragon et al., 2012; Sala et al., 2011). A and B type dives are associated with travelling, C dives are resting periods, D are considered to be prey pursuit dives, and E_b and E_f are associated with benthic feeding and resting.

Elephant seals may have poor in-air hearing sensitivity due to their aquatic and deep-diving lifestyle. Their ears may be better adapted for in-water hearing in terms of energy efficiency, which is reflected in the lower intensity thresholds under water, as well as receiving and transducing the mechanical stimulus which is reflected in the lower pressure thresholds under water (Kastak and Schusterman, 1999). Kastak and Schusterman (1999) found that hearing sensitivity in air is generally poor, but the best hearing frequencies were found to be between 3.2 and 15 kHz with the greatest sensitivity at 6.3 kHz and an upper frequency limit of 20 kHz (all at 43 dB re: 20 µPa). Underwater, the best hearing range was found to be between 3.2 and 45 kHz, with greatest sensitivity at 6.4 kHz and an upper frequency limit of 55 kHz (all at 58 dB RL) (Kastak and Schusterman, 1999). Kastak and Schusterman (1998) found that northern elephant seals can hear underwater sounds in the range of 75 Hz to 6.3 kHz. They found hearing sensitivity increased for frequencies below 64 kHz, and the animals were still able to hear sounds below 100 Hz. One juvenile was measured as having a hearing threshold of 90 dB RL at 100 Hz (Fletcher et al., 1996). Since their hearing is better underwater, it is assumed that elephant seals are more sensitive to anthropogenic low frequency sound (Kastak and Schusterman, 1998). There are no direct hearing data available for southern elephant seals.

Elephant seals have developed high-amplitude, low-frequency vocal signals that are capable of propagating large distances. Elephant seals are highly vocal animals on their terrestrial rookeries and are not known to make any vocalizations underwater. Their in-air vocalizations are important for maintaining a social structure. Both sexes of all age classes are vocal. Two main sounds are produced by adults: calls of threat and calls to attract a mate. Yearlings often make a hissing sound (Bartholomew and Collias, 1962). The harmonics in pup calls may be important for individual recognition, extending to frequencies of 2 to 3 kHz (Kastak and Schusterman, 1999). The calls made by males are typically low-frequency, around 175 Hz (Fletcher et al., 1996).

Male northern elephant seals make three in-air sounds during aggression: snorting (200 to 600 Hz, clap threat (up to 2.5 kHz), and snoring (Frankel, 2009). In the air, mean frequencies for adult male northern elephant seal vocalizations range from 147 to 334 Hz (Le Boeuf and Peterson, 1969; Le Boeuf and Petrinovich, 1974). (Burgess et al., 1998) recorded 300 Hz pulses from a juvenile female elephant seal between 220 to 420 m (722 to 1,378 ft) dive depths. Adult female northern elephant seals have been recorded with airborne call frequencies of 500 to 1,000 Hz (Bartholomew and Collias, 1962). Pups produce a higher frequency contact call up to 1.4 kHz (Frankel, 2009). There are no available data regarding seasonal or geographical variation in the sound production of either species.

4.3.2.4 Ribbon Seal (*Phoca fasciata*)

Ribbon seals are classified as a data deficient species by the IUCN. Although no current abundance estimates are available for the global population, Fedoseev (2000) reported an average population of 370,000 ribbon seals in the Sea of Okhotsk between 1968 and 1990, but more recently, 124,000 ribbon seals have been estimated to occur in the Sea of Okhotsk (Boveng et al., 2013). The Alaska stock of ribbon seals is estimated to include 184,000 individuals (Conn et al., 2014; Muto et al., 2016) and the North Pacific stock is estimated to include 61,100 individuals (Allen and Angliss, 2015).

The distribution of ribbon seals is limited to the northern North Pacific Ocean and an area of the Arctic Ocean north of 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 phase that may encompass a broader distributional range than when the seals are dependent upon sea ice (Jefferson et al., 2008). Swim speeds are unknown and few dive data are known for this species. Fedoseev (2002) reported that ribbon seals are well adapted for fast swimming and deep diving. 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).

There is no direct measurement of auditory threshold for the hearing sensitivity of the ribbon seal (Thewissen, 2002). Ribbon seals produce underwater sounds between 100 Hz and 7.1 kHz with an estimated SEL recorded at 160 dB (Watkins and Ray, 1977). These seals produce two types of underwater vocalizations, short, broadband puffing noises and downward-frequency sweeps 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). These authors speculated that these sounds are made during mating and for defense of their territories. There are no available data regarding seasonal or geographical variation in the sound production of this species.

4.3.2.5 Spotted Seal (*Phoca largha*)

Spotted or largha seals are classified as a data deficient species by the IUCN. The Southern DPS of spotted seals, which consists of breeding concentrations in the Yellow Sea and Peter the Great Bay in China and Russia, is listed as threatened under the ESA. The global population for this species is unknown. 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. The last reliable population estimate for the Alaska stock/Bering Sea DPS was 460,268 seals (Allen and Angliss, 2015). 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 et al., 2009; Han et al., 2010; Nesterenko and Katin, 2008).

Spotted seals occur in temperate to polar regions of the North Pacific Ocean from the Sea of Okhotsk, the Sea of Japan, and the Yellow Sea to the Bering and Chukchi Seas into the Arctic Sea to the Mackenzie River Delta (Jefferson et al., 2015). Spotted seals spend their time either in open-ocean waters 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. The range of spotted seals contracts and expands in association with the ice cover; 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. These animals spend the summer and fall near Point Barrow in Alaska and the northern shores of Chukotka, Russia. With increasing ice cover, the 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). Swim speeds range from 0.2 to 2.8 kt (0.4 to 5.2 kph), with an average speed of 1.2 ± 0.4 kt (2.2 ± 0.8 kph) have been observed (Lowry et al., 1998). Dive times of this species are not known. 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).(

Spotted seals can hear underwater from 300 Hz to 56 kHz. Their best sensitivity is between 2 and 30 kHz, with threshold of ~ 55 dB (Sills et al., 2014). Underwater vocalization of captive seals increased 1 to 2 weeks before mating and was higher in males than females. Sounds produced were growls, drums, snorts, chirps, and barks ranging in frequency from 500 Hz to 3.5 kHz (Richardson et al., 1995).

4.3.2.6 Harbor Seal (*Phoca vitulina*)

Harbor seals are also known as common seals. This species is classified as least concern (lower risk) by the IUCN. The global population of harbor seals is estimated to be between 400,000 and 500,000 seals (Jefferson et al., 2015). Five subspecies of the harbor seal have been classified throughout the Northern Hemisphere. In the western North Atlantic there are an estimated 75,834 seals (Waring et al., 2015). In Alaska including the Gulf of Alaska and the Bering Sea, the statewide population of harbor seals is estimated to be 152,592 individuals (Allen and Angliss, 2015). The California stock estimate of harbor seals is estimated to be 30,968 seals (Carretta et al., 2015). The numbers in Oregon and Washington are currently unknown. The Northwest Europe population of harbor seals has been estimated to include 40,414 individuals (SCOS, 2015).

Harbor seals are one of the most widely distributed pinnipeds in the world. This species is widely distributed in Polar and temperate waters along the margins of the eastern and western North Atlantic Ocean, and the North Pacific Ocean (Jefferson et al., 2015). They also can be found in the southern Arctic Ocean (Jefferson et al., 2015). This species is most commonly found in coastal waters of the continental shelf waters, and can be found in rivers, bays, and estuaries (Jefferson et al., 2015). They primarily inhabit areas that are ice-free. The greatest numbers of breeding animals occur in the northern temperate zone. However, breeding colonies occur both north and south of the zone, depending on environmental, oceanic, and climate conditions.

Harbor seals are generally considered to be sedentary, but their known seasonal and annual movements are varied. They haul out mainly on land, but they do use icebergs in Alaska and Greenland. When they haul out on land, they prefer natural substrates of mud flats, gravel bars and beaches, and rocks.

Breeding grounds are generally associated with isolated places such as pack ice, offshore rocks, and vacant beaches (Riedman, 1990).

Maximum swim speeds have been recorded over 7 kt (13 kph) (Bigg, 1981). The deepest diving harbor seal was located in Monterey Bay, California, and dove to a depth of 1,578 ft (481 m), and the longest dive lasted 35.25 min (Eguchi and Harvey, 2005). In general, seals dive for less than 10 min, and above 492 ft (150 m) (Jefferson et al., 2015).

Hanggi and Schusterman (1994) and Richardson et al. (1995) reported harbor seal sounds. Social sounds ranged from 0.5 to 3.5 kHz, Clicks range from 8 to more than 150 kHz with dominant frequencies between 12 and 40 kHz. Roars range from 0.4 to 4 kHz with dominant frequencies between 0.4 and 0.8 kHz. Bubbly growls range from less than 0.1 to 0.4 kHz with dominant frequencies at less than 0.1 to 0.25 kHz. Grunts and groans range from 0.4 to 4 kHz. Creaks range from 0.7 to 7 kHz with dominant frequencies between 0.7 and 2 kHz. This species creates a variety of sounds including clicks, groans, grunts, and creaks.

Van Parijs et al. (2000) studied the variability in vocal and dive behavior of male harbor seals at both the individual and the geographic levels. Harbor seals are an aquatic-mating species. The females are forced to forage to sustain a late lactation. For this reason, harbor seals are widely distributed throughout the mating season. Male harbor seals produce underwater vocalizations and alter their dive behavior during mating season. In Scotland, male harbor seals are found to alter their dive behavior in the beginning of July for the mating season. They change from long foraging dives to short dives. Changes in dive behavior during the mating season have also been reported in Norway and Canada. Individual variation in vocalization of male harbor seals has also been recorded in California breeding populations. Male vocalizations also varied individually and geographically in Scotland. This study showed the variability in male vocalizations individually and geographically, as well as the change in dive behavior (Van Parijs et al., 2000).

Van Parijs and Kovacs (2002) studied the eastern Canadian harbor seal in-air and underwater vocalizations. It was determined that harbor seals produce a range of in-air vocalizations and one type of underwater vocalization. The number of vocalizations increased proportionally with the number of individuals present at the haul out sites. In-air vocalizations were predominantly emitted by adult males during agnostic interactions, which suggest that in-air vocalizations are used during male competition. In-air vocalizations were also produced by adult females and sub-adult males which suggest that some types of in-air vocalizations may serve for general communication purposes. The harbor seals in the study also produced underwater roar vocalizations during the mating season. These vocalizations are similar to that of other harbor seals in other geographic locations (Van Parijs and Kovacs, 2002).

The harbor seal can hear sounds in the range of 75 Hz to a maximum of 180 kHz (Kastak and Schusterman, 1998; Møhl, 1968a; Terhune, 1991). In a study by Wolski et al. (2003), harbor seals' aerial hearing was measured using the method of constant stimuli. It was found that harbor seals have good sensitivity between 6 and 12 kHz, and the best sensitivity at 8 kHz at 8.1 dB re 20 $\mu Pa^2 s$ (Wolski et al., 2003). Underwater hearing thresholds are ~ 53 dB @ 4 kHz (Kastelein et al., 2010).

4.3.2.7 Atlantic Gray Seal (*Halichoerus grypus atlantica*)

Gray seals are classified as a least concern (lower risk) species by the IUCN. Gray seals have a global population estimate of 400,000 to 500,000 seals, including 22,000 in the Baltic Sea (Jefferson et al., 2015). The gray seal's Northwest Europe population has been estimated to include 116,800 individuals (Special Committee on Seals [SCOS], 2015).

Gray seals occur in temperate and sub-polar regions mostly in the North Atlantic Ocean, Baltic Sea, and the eastern and North Atlantic Ocean (Jefferson et al., 2015). Gray seals breed on remote islands that are typically uninhabited or on fast ice. The largest island breeding colony is on Sable Island (Hall and Thompson, 2009). This species is not known to undergo seasonal movements.

Swim speeds average 2.4 kt (4.5 kph). Gray seals dives are short, between 4 and 10 min, with a maximum dive duration recorded at 30 min (Hall and Thompson, 2009). A maximum dive depth of over 984 ft (300 m) has been recorded for this species, but most dives are relatively shallow, from 197 to 328 ft (60 to 100 m) to the seabed (Hall and Thompson, 2009).

Gray seals' underwater hearing range has been measured from 2 kHz to 90 kHz, with best hearing between 20 kHz and 50 to 60 kHz (Ridgway and Joyce, 1975). Gray seals produce in-air sounds at 100 Hz to 16 kHz, with predominant frequencies between 100 Hz and 4 kHz for seven characterized call types, and up to 10 kHz for "knock" calls (Asselin et al., 1993). Oliver (1978) has reported sound frequencies as high as 30 and 40 kHz for these seals. There are no available data regarding seasonal or geographical variation in the sound production of gray seals.

4.3.2.8 Pacific Bearded Seal (*Erignathus barbatus nauticus*)

Two DPSs of Pacific bearded seals have been recognized but only the Okhotsk DPS is listed as threatened under the ESA and depleted under the MMPA. Only the Alaska stock is located in U.S. waters. While not considered accurate, the global bearded seal population has been estimated at over 500,000 seals. The population of bearded seals in the Sea of Okhotsk is estimated as 200,000 seals (Cameron et al., 2010; Fedoseev, 2000; Laidre et al. 2015); the Okhotsk DPS is thought to have declined from this estimate from the 1960s to early 1990s (Cameron et al., 2010). An outdated estimate of the Beringia DPS (Pacific bearded seals that occur in continental shelf waters of the Bering, Chukchi, Beaufort, and East Siberian seas) reported the DPS as including about 155,000 seals, but uncompleted analysis of a 2012 to 2013 survey report a preliminary population estimate of the Bering Sea bearded seals as 299,174 (Allen and Angliss, 2015).

Bearded seals have a circumpolar distribution in the Northern Hemisphere that does not extend further north than 80°N. The Pacific bearded seal is distributed from the Laptev Sea eastward to the central Canadian Arctic and southward to the Sea of Okhotsk and northern Japan (Kovacs et al. 2008a). Bearded seals commonly occur in association with sea ice and individual seals move north and south as the pack ice advances and recedes seasonally, although some bearded seals remain near shorefast ice year-round. The distribution of bearded seals appears to be strongly associated with shallow water (650 ft [200 m]) due to depth at which they feed on benthic prey.

Bearded seals most routinely dive between 16 and 262 ft (5 and 80 m) (Gjertz et al., 2000b; Krafft et al., 2000). Dive studies of female bearded seals in the Svalbard Archipelago indicate that bearded seals make shallow dives, generally <328 ft (<100 m) in depth, and for short periods, generally less than 10 min in duration (Cameron et al., 2010). By the time bearded seal pups are 6 weeks of age, they are capable of diving to maximum dive depths similar to those of lactating females, 1470 to 1575 ft (448 to 480 m) (Gjertz et al., 2000b). Adult females spent most of their dive time (47 to 92 percent) performing U-shaped dives, believed to represent bottom feeding (Krafft et al., 2000). Gjertz et al. (2000b) reported a mean maximum dive depth of 951 ft (290 m). Routine dive times range from 1 to 5.4 min., with a maximum dive time of about 10 min (Gjertz et al., 2000b). Bearded seals are capable of swimming from 1.2 to 3.1 kt (2.2 to 5.8 kph).

Little is known about the hearing of bearded seals. Phocid seals probably hear sounds underwater at frequencies up to about 60 kHz. Above 60 kHz, their hearing is poor. Male bearded seals vocalize during the spring breeding season using four types of calls: trills, ascents, sweeps, and moans that have described as FM vocalizations (Davies et al. 2006, Risch et al. 2007; Van Parijs et al. 2004, Van Parijs and Clark, 2006). They produce distinctive, stereotyped calls ranging from 0.02 to 11 kHz in frequency. As they sing, bearded seals dive slowly in a loose spiral, releasing bubbles and finally surfacing in the center of the circle they've made. Each male's vocalizations are unique and they return to a specific breeding territory each year for mating, with a peak in calling occurring during and after pup rearing (Chapskii, 1938; Dubrovskii, 1937; Freuchen, 1935). Trills show marked individual and geographical variation, are uniquely identifiable over long periods, can propagate up to 30 km, are up to 60 s in duration, and are usually associated with stereotyped dive displays (Cleator et al., 1989; Van Parijs et al., 2001; Van Parijs, 2003; Van Parijs et al., 2003; Van Parijs et al., 2004; Van Parijs and Clark, 2006). The vocalizations are only heard during the breeding season which lasts for about 90 days, from about late March through mid July. Frouin-Mouy et al. (2016) suggested that these trill vocalizations are the way of male bearded seals advertising their breeding condition. Frouin-Mouy et al. (2016) also found that the vocalization rate increased with the advent of sea ice formation in winter and that vocalization rates were at night than during the day.

4.3.2.9 Arctic Ringed Seal (*Pusa hispida hispida*) and Okhotsk Ringed Seal (*Pusa hispida ochotensis*)

Two of the subspecies of ringed seals, the Arctic and Okhotsk, occur in the potential global operating areas for SURTASS LFA sonar. The Okhotsk ringed seal is listed as threatened under the ESA while both the Arctic and Okhotsk subspecies are considered depleted under the MMPA. Critical habitat under the ESA has been proposed for the Arctic ringed seal in the northern Bering, Chukchi, and Beaufort seas, marine habitat that is not included in SURTASS LFA sonar's potential operating area. No accurate global population estimates for the ringed seal exist due to the widely disbursed distribution over vast geographic regions, but Miyazaki (2002) estimated the global population as 2.5 million ringed seals. Even though the Arctic ringed seal population is the most abundant of all the ringed seal subspecies, an overall population estimate doesn't exist. In the Atlantic Arctic region, including the Labrador Sea, the Arctic ringed seal population has been estimated population was 787,000 individuals (Finley et al., 1983; Kelly et al., 2010), and an estimated 300,000 seals in the Beaufort and Chukchi seas region of the Arctic (Allen and Angliss, 2015; Kelly et al., 2010). The population of Okhotsk ringed seals was estimated recently as 676,000 seals (Fedoseev, 2000; Kelly et al., 2010).

Ringed seals have a circumpolar distribution generally north of 35°N and are found at least seasonally in all ice-covered seas of the Northern Hemisphere as well as in certain freshwater lakes (King, 1983). The Arctic ringed seal occurs in the Arctic Ocean and its adjacent seas, including the Bering Sea and Hudson Bay, while the Okhotsk ringed seal occurs in the Sea of Okhotsk and the waters off northern Japan (Kovacs et al., 2008a). Ringed seals are considered ice seals, being well adapted to living on firm ice, including both pack ice and shorefast ice, and aren't commonly found in open ocean waters. These seals maintain contact with the ice, migrating in response to the seasonal ice advances and retreats.

Ringed seals spend about 20 percent of their time at sea diving, with average dive times ranging from 1 to 2.7 min, although Lydersen (1991) reported a maximum ringed seal dive of 17 min. Ringed seals typically make the majority of their dives to water depths ranging from 33 to 164 ft (10 to 50 m), with few daily dives to depths greater than 492 ft (150 m) (Gjertz et al., 2000a; Lydersen, 1991; Simpkins, 2000). The maximum dive depth reported for ringed seals is 1,181 ft (360 m) (Born et al., 2004). Ringed seal swim speeds average between about 0.9 to 1.2 kt (1.6 to 2.2 kph), with the maximum speed recorded as 5.8 kt (10.8 kph) (Born et al., 2004; Lowry et al., 1998; Simpkins et al., 2001; Teilmann et al., 1999).

Terhune and Ronald (1975a, 1975b) reported that ringed seal audiograms show that they can hear frequencies as low as 1 kHz but their hearing thresholds are relatively flat from 1 to 50 kHz, with thresholds between 65 and 85 dB RL. Terhune and Ronald (1976) measured the upper frequency limit of ringed seal hearing as 60 kHz. More recently using psychophysical methods to measure the in-air and underwater hearing of ringed seals, Sills et al. (2015) reported the best hearing sensitivity of ringed seal hearing in water as 12.8 kHz (49 dB re 1 µPa), which was lower than previously reported by Terhune and Ronald (1975a and 1975b), while the in air best hearing sensitivity was reported as 4.5 kHz (−12 dB re 20 µPa). Sills et al. (2015) also reported critical ratio measurements that ranged from 14 dB at 0.1 kHz to 31 dB at 25.6 kHz, which suggested that ringed seals possess enhanced signal detection capabilities such that they can efficiently extract signals from background noise across a broad range of frequencies. Moreover, critical ratios were measured over the full vocal range of ringed seals, but no correlation was shown with the frequencies of ringed seal vocalizations (Sills et al., 2015).

Ringed seal underwater vocalizations have been hypothesized to support the maintenance of social structure around breathing holes in winter and spring (Stirling, 1973; Stirling et al., 1983). Stirling (1973) described barks, yelps, high-pitched growls, and chirps of ringed seals that extended up to a maximum of about 6 kHz. Cummings et al. (1981) described a gargle-type vocalization with peak energy at 1 kHz and a rub sound that extended from 0.7 to 2.6 kHz in range. The typical energy of ringed seal calls is between 0.1 and 5 kHz (Stirling, 1973; Stirling et al., 1983; Cummings et al., 1984; Jones et al., 2014). Sills et al. (2015) reported that contrary to the notion that animals vocalize in the same frequency range of their hearing, the range of ringed seals' best hearing extends to more than three octaves above the upper limit of ringed seals dominant vocalization energy.

4.3.2.10 Hooded Seal (*Cystophora cristata*)

Hooded seals are classified as a vulnerable species by the IUCN. The global population of hooded seals is estimated at 660,000 seals (Kovacs, 2009), with the western North Atlantic population estimated to include 592,100 seals (Waring et al., 2008). Three stocks are recognized to set harvest quotas: Canadian, Davis Strait, and the West Ice (west of Jan Mayen Island) stocks (Kovacs, 2009). The abundance of the West Ice stock has been stable for the last 20 years (Kovacs, 2009) and is currently estimated as 84,020 hooded seals (ICES, 2013).

Hooded seals are found in the high latitudes of the North Atlantic Ocean, and in the Arctic Ocean (Jefferson et al., 2015). Hooded seals are solitary animals except when breeding or molting and are found in the deeper waters of the North Atlantic, primarily off the east coast of Canada, Gulf of St. Lawrence, Newfoundland, Greenland, Iceland, Norwegian waters, and the Barents Sea (Kovacs, 2009). Their winter distribution is poorly understood, but some seals inhabit the waters off Labrador and northeastern Newfoundland, on the Grand Bank, and off southern Greenland (Jefferson et al., 2015). Hooded seals are associated with the outer edge of pack ice and drifting ice throughout much of the year, moving with the drifting pack ice; seals congregate on ice floes for both mating and pupping (Kovacs, 2009). Hooded seals are a migratory species and are often seen far from their haul-outs and foraging sites. Records of migrant hooded seals are not unusual, with juveniles having been observed as far south as Portugal, the Caribbean Sea, and California (Mignucci-Giannoni and Odell, 2001).

No data on hooded seal swim speeds are available. Hooded seals appear to dive nearly continuously when at sea, being submerged for over 90 percent of time at sea (Folkow and Blix, 1999). Diving behavior differs between males and females as well as during different behaviors and life phases (e.g., migrating, molting, and breeding). The mean surface time for both sexes is 1.8 min. Andersen et al. (2013) reported mean dive durations of 13.9 min and a maximum dive duration of 57.3 min, with mean dive depth of 837 ft (255 m) and a maximum depth of 5,420 ft (1,652 m). Hooded seals generally dive deeper and longer at night (Folkow and Blix, 1999). Hooded seals have been observed to perform drift dives (Andersen et al., 2014).

There is no direct measurement of auditory threshold for the hearing sensitivity of the hooded seal (Thewissen, 2002). They have been shown to respond to sonar signals between 1 and 7 kHz (Kvadsheim et al., 2010). Hooded seals produce a variety of distinct sounds ranging between 500 Hz and 6 kHz (Frankel, 2009). There are at least three types of LF, pulsed sounds, described as grunt, snort, and buzz that are made by the male underwater. The grunt noise has the highest intensity in the 0.2 and 0.4 kHz range (Terhune and Ronald, 1973). The snort has a broad band of energy ranging between 0.1 and 1 kHz with harmonics occasionally reaching 3 kHz. The buzz has most of its energy at 1.2 kHz with side bands and harmonics reaching 6 kHz (Terhune and Ronald, 1973). All three calls exhibited some pulsing. Female calls in air have major intensities at frequencies of less than 0.5 kHz with a low harmonic and an exhalation of 3 kHz at the end of the call. The sounds produced by hooded seals have a variety of functions ranging from female-pup interactions to fighting behavior and visual displays among males (Terhune and Ronald, 1973; Frankel, 2009). The source levels of these sounds have not been estimated, and there are no available data regarding seasonal or geographical variation in the sound production of hooded seals.

4.3.2.11 Harp Seal (*Pagophilus groenlandicus*)

The harp seal is considered least concern by the IUCN. Worldwide population is estimated at 9 million seals (Jefferson et al., 2015). Three populations of harp seals are recognized: western North Atlantic, White Sea-Barents Sea, and the Greenland Sea. Only the western North Atlantic population of harp seals potentially occurs in waters in which SURTASS LFA sonar may operate. The western North Atlantic population of harp seals was estimated as 7,411,000 seals for 2014 (Department of Fisheries and Oceans [DFO], 2014).

Harp seals only occur in the North Atlantic and Arctic Oceans and adjacent seas from northern Russia to Newfoundland and the Gulf of St. Lawrence, Canada in three defined stocks: the “Front” or northwest Atlantic (Newfoundland, Labrador, and the Gulf of St. Lawrence), the “West Ice” or Greenland Sea near Jan Mayen Island, and the “East Ice” in the Barents and White Seas (Waring et al., 2009). Since 1994, however, increasing and substantial numbers of harp seals, often juveniles, have been recorded in the western North Atlantic from the Gulf of Maine southward to New Jersey (Harris et al., 2002; McAlpine and Walker, 1990; McAlpine and Walker, 1999), In the nearly 150 years prior to 1994, only 16 harp seals were reported in the northern Gulf of Maine, while recently more than that number are now reported annually in the Gulf of Maine and southern New England (McAlpine et al., 1999; Waring et al., 2009). Reports of increasing numbers of reported harp seals along the coast of western continental Europe (Denmark to northern Spain) have also reported within the same time period (Van Bree, 1997). The southern limit of the harp seal’s range in the western North Atlantic is now considered to extend into the northeastern U.S. waters during winter and spring (Waring et al., 2009). One seal was found in poor condition and died in the Mediterranean Sea (Bellido et al., 2009).

Previously, harp seals were thought to be shallow divers, but dives to maximum water depths of 568 m (Folkow et al., 2004) and dive durations up to 16 min (Schreer and Kovacs, 1997) now demonstrate that harp seals are moderately deep divers. Folkow et al. (2004) found that more than 12 percent of all dives recorded during their study were to depths more than 300 m. Harp seal's mean dive durations range from 3.8 to 8.1 min (Folkow et al., 2004; Lydersen and Kovacs, 1993).

The ear of the harp seal is adapted to hear better underwater than in air, as demonstrated by the decreased hearing sensitivity measured in air (Terhune and Ronald, 1971). In-water, harp seals hearing was measured by free-field audiogram from 760 Hz to 100 kHz, with greatest sensitivity at 2 and 23 kHz and thresholds between 60 and 85 dB re 1 µPa (Richardson et al., 1995; Terhune and Ronald, 1972), while the in-air audiogram, measured from 1 to 32 kHz, has the lowest threshold at 4 kHz while the frequency range from 16 to 32 kHz remains constant (Terhune and Ronald, 1971; Ronald and Healey, 1981). Above 64 kHz, the in-water hearing threshold increases by 40 dB per octave (Ronald and Healey, 1981).

Harp seals produce as many as 26 different underwater vocalizations that are usually short in duration and have been described as whistles, grunts, trills, chirps, clicks, knocks, and squeaks (Ronald and Healey, 1981; Serrano, 2001). These seals are especially vocal during breeding, producing as many as 135 calls/min (Serrano and Terhune, 2002). Frequencies of the varied in-water vocalizations range from about 400 to 849 Hz while in-air vocalizations are lower, at about 206 Hz (Serrano, 2001). Harp seals most likely use frequency and temporal separation of their vocalizations together with a wide vocal repertoire (as many as 26 call types) to avoid masking one another (Serrano and Terhune, 2001). Source levels range between 103 and 180 dB re 1µPa at 1 m (Rossong and Terhune, 2009).

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 subsequent annual LOAs for the employment of SURTASS LFA sonar during routine training, testing, and military operations. 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) during periods of not more than five consecutive years. 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 will have a negligible impact on the species and stocks of marine mammals and will not have an unmitigable adverse impact on their availability for subsistence uses. Marine mammals will be incidentally harassed by the underwater sound generated during employment of SURTASS LFA sonar. As a result, the Navy is requesting rulemaking under the MMPA with subsequent applications for annual LOAs for the taking of marine mammals by Level A (non-lethal) and Level B harassment incidental to the employment of up to four SURTASS LFA sonar systems within restricted areas of the world's oceans for the five year period from August 2017 through August 2022.

This application for rulemaking and LOAs is the fourth such application the Navy has submitted to NMFS for employment of SURTASS LFA sonar. In 2002, NMFS issued regulations and the initial LOA (NOAA, 2002) under the MMPA Final Rule (50 CFR §216 Subpart Q) (NOAA, 2002) for the operation of SURTASS LFA sonar on the 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 USNS IMPECCABLE. In 2006, the Navy submitted its application for the second five-year Rule under MMPA (DoN, 2006) for the taking of marine mammals by Level A and Level B harassment 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 in 2007 issued annual LOAs for sonar use on the RV *Cory Chouest,* USNS ABLE, USNS VICTORIOUS, and USNS IMPECCABLE. In 2011, the Navy submitted its application for the third five-year Rule under MMPA (DoN, 2011) for the taking of marine mammals by Level A and Level B harassment incidental to the deployment of up to four SURTASS LFA sonar systems for military readiness activities 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 in 2012 issued annual LOAs for sonar use on the USNS VICTORIOUS, USNS ABLE, USNS EFFECTIVE, and USNS IMPECCABLE.

This application document has been prepared in accordance with applicable regulations and the MMPA, as amended by the NDAA for Fiscal Year 2004. 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 rulemaking and LOA request are (1) the analysis of spatial and temporal distributions of protected marine mammals in potential mission areas for SURTASS LFA sonar, (2) a review of activities that have the potential to affect marine mammals, and (3) a technical risk assessment to determine the likelihood of impacts from use of SURTASS LFA sonar during Navy routine training, testing, and military operations in the world's oceans, with specific geographic areas exempted from operations.

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.

For SURTASS LFA sonar operations, potential impacts to marine mammals should be assessed in the context of the basic operational characteristics of the system:

- A maximum of four operating sonar systems aboard four SURTASS LFA vessels will be deployed in the Pacific, Atlantic, Indian oceans and Mediterranean Sea.
- The USNS IMPECCABLE (T-AGOS 23) is equipped with a SURTASS LFA sonar system. Three VICTORIOUS Class platforms (T-AGOS 19, 20, and 21) are equipped with CLFA systems. These vessels are U.S. Coast Guard-certified for operations. In addition, these vessels will 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 part of routine operations of seagoing vessels. Therefore, there should be no unregulated environmental impacts from operation of the SURTASS LFA sonar vessels.
- At-sea missions would be temporary in nature. Of an estimated maximum 294 underway days per year per vessel, the SURTASS LFA sonar would be operated in the active mode a maximum of 240 days. During these 240 days, active transmissions would occur for a maximum of 255 hours per year per vessel.
- Average duty cycle (ratio of sound "on" time to total time) of SURTASS LFA sonar is less than 20 percent. 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 to the water.

The types of potential impacts on marine mammals from SURTASS LFA sonar operations 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.
- **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 employment of SURTASS LFA sonar, Level B incidental "harassment" under the MMPA is defined as any act that disturbs or is likely to disturb a marine mammal by causing disruption of natural behavioral patterns to a point where the patterns are abandoned or significantly altered.
- **Masking**: The presence of intense sounds in the environment can potentially interfere with an animal's ability to hear relevant sounds. This impact, known as "auditory masking", could interfere with the animal's ability to detect biologically-relevant sounds, such as those produced by predators, prey, or reproductively active mates. During auditory masking, an animal may, thus, not be able to escape predacious attack, locate food, or find a reproductive partner.
- **Physiological stress**: Exposure to underwater sound may evoke a response in a physiological mediator (e.g., glucocorticoids, cytokines, or thyroid hormones) (Atkinson et al., 2015). The type, duration, and magnitude of the stress response may have a metabolic cost, which is termed the allostatic load. How stress responses might be linked to individual- and population-level consequences is an area much in need of research (National Research Council [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) and related conclusions are incorporated by reference herein.

The consequences of direct acoustic impacts, such as ear bulla fractures, were elucidated in a recent study of museum specimens (Yamato et al., 2016). A review of 2,127 skulls found eleven examples of well-healed fractures, suggesting that marine mammals are capable of surviving traumatic injury to the ear. The study was not able to determine the cause of the ear bulla fractures, although disease and external pressure waves were considered.

Additional research on gas bubble occurrence and composition attempted to shed light on the potential for gas bubble formation due to sound exposure. Dennison et al. (2012) examined 22 live stranded dolphins for the presence of gas bubbles using ultrasound. Bubbles were identified in the kidneys of 21 of the 22 dolphins and in hepatic portal blood vessels of two of the 22 animals. Nine of the dolphins died, and the presence of the bubbles in their tissues was confirmed with necropsy and computer tomography. Thirteen of the 22 dolphins were released; of those thirteen, only two restranded, suggesting that minor bubble formation is tolerable and does not necessarily lead to decompression sickness.

Bernaldo de Quirós et al. (2012) examined the amount of bubbles and the time since death to compare measurements made on deep divers and non-deep divers during 88 necropsies. Not surprisingly, the number of bubbles increased with time since death. When considering only recently dead animals, the amount of bubbles was greater in deep divers than in non-deep diving species. Bernaldo de Quirós et al. (2013) suggest that the composition of gases found in the bubbles can be used to discriminate whether the bubbles formed from decomposition or decompression. Examining by-caught animals that were held at depth in nets and then quickly raised to the surface, they found that the by-caught animals had a greater number of bubbles, consistent with decompression of supersaturated tissues. They were also able to examine the increase of putrefaction gases in different tissues, finding that bubbles in the coronary veins were the slowest to show impacts of decomposition.

The above scientific studies do not provide new data to contradict any of the assumptions or conclusions in previous LFA documentation (DoN, 2007, 2012), especially the conclusion that SURTASS LFA sonar transmissions are not expected to cause gas bubble formation or strandings, particularly those of beaked whales.

6.2 Auditory Impacts

The most well-understood 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 TTS and the level, duration, and frequency of the stimulus (Finneran, 2015; NOAA, 2016a). 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. The best available data are used for the analysis of potential auditory impacts and, when necessary, conservative assumptions are implemented that aim to provide the greatest protection to marine animals. The detailed descriptions and information on auditory impacts provided in previous documentation for SURTASS LFA sonar (DoN, 2007, 2012) are incorporated by reference herein. Summaries of additional recent research and analysis methods on auditory impacts are described below.

The potential for PTS and TTS was evaluated as MMPA Level A harassment for all marine mammals at RLs greater than or equal to 180 dB rms in preceding SURTASS LFA sonar EISs (DoN, 2007, 2012), even though NMFS stated that TTS is not a physical injury in MMPA rulemaking for SURTASS LFA sonar (NOAA, 2002, 2007, 2012a). However, the Navy considered TTS as part of MMPA Level A harassment since such limited data existed on how LF hearing specialists are affected by LFA sonar. Since the 2012 SEIS/SOEIS was released, NOAA published acoustic guidance that incorporates new data and summarizes the best available information. The guidance is described below, but it defines functional hearing groups, develops auditory weighting functions, and identifies acoustic threshold levels at which PTS and TTS occur (NOAA, 2016a). The Navy used this methodology for estimating the potential for PTS and TTS for SURTASS LFA sonar. The revised methodology is described as follows.

NOAA (2016a) has finalized their guidance for assessing the impacts of anthropogenic sound on marine mammals under their regulatory jurisdiction, which includes whales, dolphins, seals, and sea lions. NOAA’s guidance specifically identifies the received levels, or acoustic threshold levels, above which individual marine mammals are predicted to experience changes in their hearing sensitivity (PTS or TTS) for acute, incidental exposure to underwater sound.

Recognizing that marine mammal species do not have equal hearing capabilities, five functional hearing groups of marine mammals were defined:

- <u>Low-frequency (LF) Cetaceans</u>—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; NOAA, 2016a). 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.

NOAA (2016a) defined acoustic threshold levels at which PTS is predicted to occur for each functional 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). It is unlikely that such an analysis will be possible for the majority of marine species because of the difficulties associated with collecting the necessary information (Tougaard et al., 2015).

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

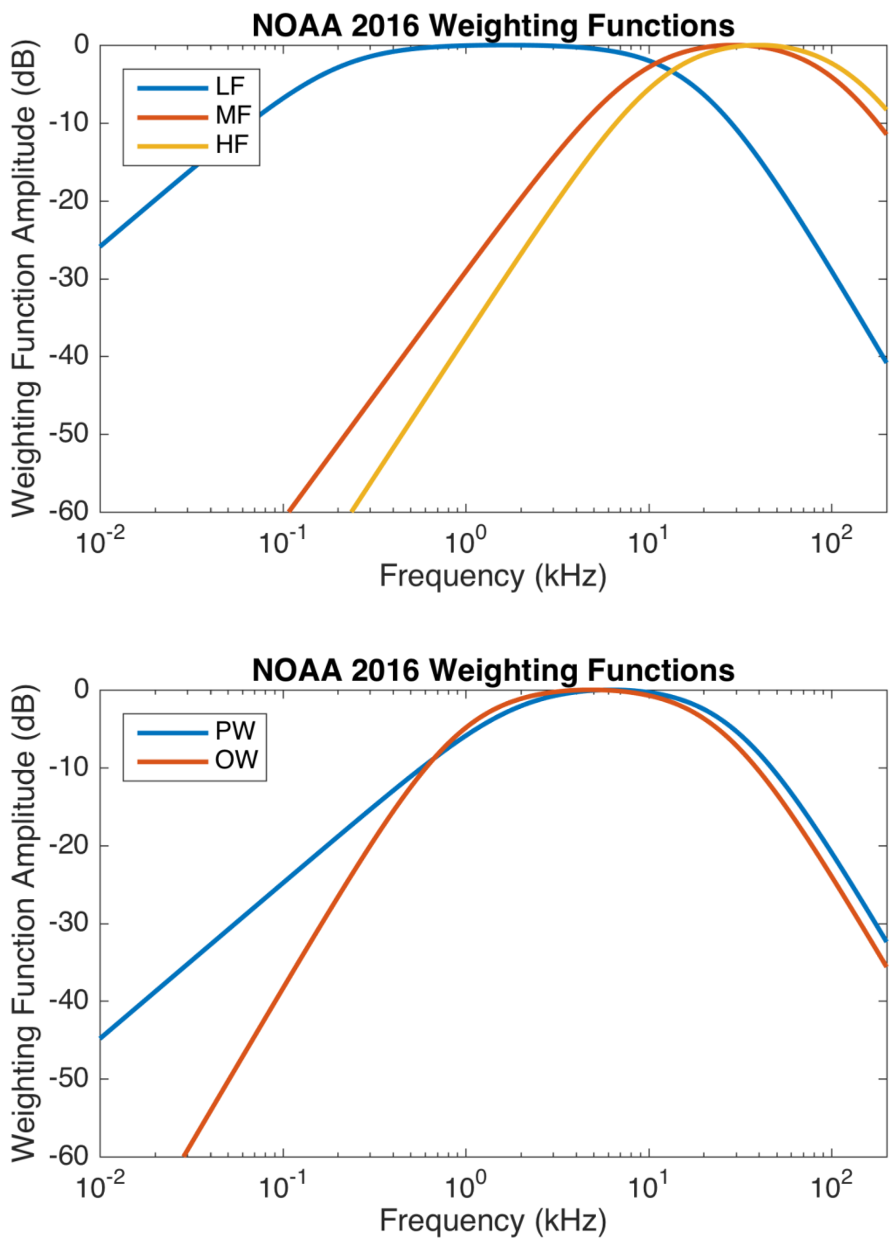

Figure 6-1. Auditory Weighting Functions for Cetaceans (Top Panel: LF, MF, and HF Species) and Pinnipeds (Bottom Panel: PW, OW) (NOAA, 2016a).

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 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 170-178 dB re 1µPa.

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

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

However, when the source was moved offshore to the edge of the migratory corridor, with an increased SL to maintain the same received levels at the whales, the migrating gray whales exhibited no response to the LFA stimulus (Clark et al., 1999). The context of an exposure scenario is clearly important for determining the probability, magnitude, and duration of a response (Ellison et al., 2012).

The results of the LFS SRP were used to derive the LFA risk continuum function, from which the potential for biologically significant behavioral response is calculated as described in the impact analysis section below. This function has been described in detail in the Navy's 2001, 2007, and 2012 SEISs for SURTASS LFA sonar (DoN, 2001, 2007, 2012), which as previously noted are incorporated by reference. The risk continuum is based on the premise that a smooth, continuous function that maps RL to risk is most appropriate for defining the potential or risk for a biologically significant behavioral response (Figure 6-2). A summary of the risk continuum function follows; the reader is referred to Appendix B in the Draft SEIS/SOEIS (DoN, 2016a) for additional details.

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 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 since 2012. 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,

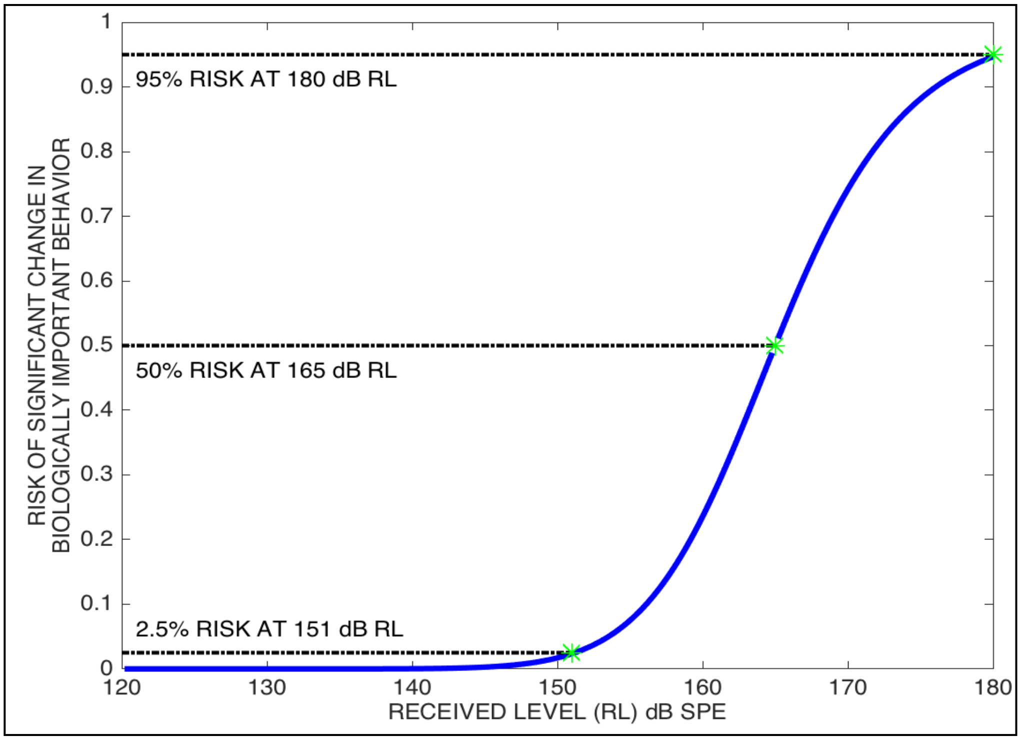

Figure 6-2. Risk Continuum Function for SURTASS LFA Sonar Analysis that Relates the Risk of Significant Change in Biologically Important Behavior to Received Levels in Decibels Single Ping Equivalent (SPE).

these data represent additional information gathered since the 2012 SEIS/SOEIS for SURTASS LFA sonar and are presented herein for awareness. Southall et al. (2012) provided an overview of the Southern California Behavioral Response Study (SOCAL-BRS). This program uses advanced tagging efforts and visual and acoustic observations to investigate behavioral responses to mid-frequency sonar signals. Blue whales exposed to simulated mid-frequency sonar showed complex, though brief, avoidance responses (Goldbogen et al., 2013). 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.

Beaked whales appear to be remarkably sensitive to noise exposure. Moretti et al. (2014) examined historical records of mid-frequency sonar operations and the vocal behavior of Blainville’s beaked whales. They were able to describe the probability of the beginning of a Group Vocal Period as a function of the received level of operational mid-frequency sonars. These data were used to create a behavioral dose-response function for Blainville’s beaked whales that has a structure similar to the LFA risk continuum, but with a 50 percent probability of response at 150 dB re 1µPa and a shallower slope (steepness parameter). Cuvier’s beaked whale responses to mid-frequency sonar have also been described (DeRuiter et al., 2013). One whale exposed to low-level simulated sonar at close ranges (RL 89 to 127 dB) responded strongly, ceasing echolocation and fluking, extended its dive duration and swam away rapidly. However, another whale incidentally exposed to distant operational mid-frequency sonars at low levels (78-106 dB) did not show a response. This variation in responses again illustrates the importance of context in interpreting these results.

Miller et al. (2015) presented a single northern bottlenose whale with a 1 to 2 kHz sonar signal. The initial received level at the animal was 98 dB re 1 µPa, and at this level the whale approached the sound source. When the level reached 130 dB re 1µPa, the whale turned 180° away and began the longest and deepest dive ever recorded for this species (94 min and 7,674 ft (2,339 m)). This one data point suggests that this species may also show marked responses to anthropogenic noise, as do many of the beaked whales.

This same bottlenose whale response, as well as those of minke and humpback whales, were examined by an expert panel to assess the severity of these responses (Sivle et al., 2015). The minke whale began avoiding the sonar signal at a received level of 146 dB re 1µPa. Eleven humpbacks were tested, and their response levels ranged from 94 to 179 dB re 1µPa. Responses were judged using a severity score table based on that of Southall et al. (2007) and modified by Miller et al. (2012) that included four subgroups: a) No response (score=0), b) Responses unlikely to affect vital rates (score=1 to 3), c) Responses with the potential to affect vital rates (score=4 to 6), and d) Responses likely to affect vital rates if repeated or of long duration (score=7 to 9). The avoidance by the minke whale and the long duration avoidance by the bottlenose whale both earned a severity score of 8. The scores of the humpback whale responses ranged from 1 to 7.

Antunes et al. (2014) presented 1 to 2 and 6 to 7 kHz simulated sonar signals to pilot whales as part of the 3S Experiment. One or more individuals within groups of long-finned pilot whales were instrumented with suction-cup-attached archival tags (DTAGs; (Johnson and Tyack, 2003)) along the coast of northern Norway (Miller et al., 2012). After a baseline, pre-exposure period, the whales were exposed to sonar signals. Source levels were increased as the vessel approached the tagged whales. The two-dimensional tracks of the animals were examined to determine the changepoint in their behavior. A dose-response curve was created, which had a 50 percent probability of behavioral change at 170 dB re 1 µPa or 173 dB SEL. While the value of the 50 percent probability of response is similar to that of the LFA risk function, the slope of their function is much shallower than the LFA function.

Killer whales were also presented with these 1 to 2 and 6 to 7 kHz FM sweeps (Miller et al., 2014). They appeared to respond with changes in swim speed and direction. The response thresholds range from 94 to 164 dB re 1µPa. The authors created a dose-response function with a 50 percent probability of avoidance value at 142 dB re 1µPa. They attributed the remarkable variation in response thresholds to intra-individual variability and other unidentified contextual values, such as proximity of the source.

Sperm whales were exposed to 1 to 2 kHz simulated naval sonar as well as playback of killer whales calls (Isojunno et al., 2016). The whales stopped foraging in response to the 1-2 kHz sonar signal at received levels of 131 to 165 dB re 1µPa as well as to the playback of the killer whales signals. No change in foraging was observed in response to the 6 to 7 kHz signals.

Harbor porpoise were exposed to 1 to 2 and 6 to 7 kHz simulated sonar signals that were composed of upsweeps and downsweeps, with and without harmonics (Kastelein et al., 2012). The 1 to 2 kHz signal with harmonics had sound energy at frequencies of 7 to 11 kHz (the harmonics) in addition to sound energy at the fundamental frequencies of 1 to 2 kHz. For 1 to 2 and 6 to 7 kHz simulated sonar signals, there was no difference in the sound level needed to cause a startle response between the upsweeps and downsweeps. However, the animals were much more sensitive to the 1 to 2 kHz signals with harmonics (50 percent response level = 99 dB re 1µPa) than without (50 percent response level = 133 dB re 1 µPa). The response level for 6 to 7 kHz signals without harmonics was 101 dB re 1 µPa. These findings highlight the importance of signal structure on behavioral response.

Henderson et al. (2014) reported on the results of visual observation of wild delphinid groups incidentally exposed to mid-frequency sonar. Twenty-six of the 46 groups (56.5 percent) encountered during MFA sonar transmissions showed some behavioral response, including changes in behavioral state or travel direction and acoustic behavior. The mean received level during responses was 122 dB re 1 µPa. However, the authors also reported that behavioral change was observed in 46 percent of the groups that were not exposed to sonar.

Houser et al. (2013b) exposed trained dolphins to mid-frequency sonar at levels from 115-185 dB re 1 µPa. They found a strong dose-response function in behavioral response to the sound. They also reported rapid habituation at RLs less than or equal to 160 dB. No habituation was observed at 175 dB and the animals refused to perform during the 185 dB condition. California sea lions exposed to the same stimuli also showed a dose-response function, although no habituation was observed (Houser et al., 2013a).

Harbor porpoise exposed to 1.33 to 1.43 kHz sonar signals with a 1.25-sec duration responded with a brief change in swimming direction or speed (Kastelein, 2013). The 50 percent response threshold ranged from RLs of 124 to 140 dB. The signal type that produced the least response (i.e., highest response threshold) was a FM downsweep without harmonics.

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 attempt to counteract masking by increasing the source level of their vocalizations in the presence of noise, known as the Lombard impact. Killer whales and belugas have been shown to increase their source level as the level of ship noise in the environment increased (Holt et al., 2011; Scheifele et al., 2005). 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 will 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 90 to 92.5 percent of the time, there is no potential for masking. Therefore, within the area in which energetic masking is possible, any impact of LFA sonar transmissions will 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.

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). 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 employing up to four SURTASS LFA sonar systems for routine training, testing, and military operations in the Pacific, Atlantic, and Indian oceans and the Mediterranean Sea. Risk assessments must provide decision-makers and regulators results that demonstrate:

- Under the MMPA, the least practicable adverse impacts on marine mammals while including consideration of personnel safety, practicability of implementation, and impact on the effectiveness of military readiness activities; and
- Under the ESA, employment of SURTASS LFA sonar is not likely to jeopardize the continued existence of threatened or endangered marine species or result in the destruction or adverse modification of critical habitat.

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), but incorporates the most current acoustic impact criteria and methodology to assess the potential for auditory impacts (PTS and TTS) and behavioral responses of marine mammal species. A summary of the analysis, as well as the exposure estimates, follow; a more thorough description of the impact analysis is provided in the Draft SEIS/SOEIS (DoN, 2016a).

Twenty-six representative mission areas in the Pacific, Atlantic, and Indian oceans and the Mediterranean Sea were analyzed to represent the acoustic regimes and marine mammal species that may be encountered during LFA sonar operations (Table 2-4). Due to the large number of potential mission areas and seasons to be considered in the impact analysis, a seasonal sensitivity study was conducted to determine the optimal modeling season for each mission area. The modeling season was chosen based on an analysis of the sound velocity profiles and resulting sound propagation and transmission loss fields, with the season with the longest range acoustic propagation typically being selected. Seasons as applied herein are defined according to the following monthly breakdown:

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

For consistency, the seasonality for marine mammals in all mission areas is presented according to this monthly arrangement, even for mission areas located in the southern hemisphere. Winter 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 26 mission areas, a list of marine mammal stocks likely to be encountered in each region was developed and abundance and density estimates derived for the selected modeling season (Chapter 3). These population data were derived from the most current published literature and documentation available.

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 at each mission area, with a signal duration of 60 sec and a duty cycle of 10 percent (i.e., the source transmitted for 60 sec every 10 min for 24 hr). The acoustic field around the LFA sonar vessel was predicted with the operating parameters of LFA sonar in the Navy standard parabolic equation propagation model. Each marine mammal species potentially occurring in a modeling area was simulated by creating animats programmed with behavioral values describing their dive behavior, including dive depth, surfacing time, dive duration, swimming speed, and direction change.

The Acoustic Integration Model© (AIM) integrated the acoustic field created from the underwater transmissions of LFA sonar with the four-dimensional (4D) movement of marine mammals to estimate their potential sonar exposure 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 PTS and then TTS was considered using the NOAA (2016a) acoustic guidance. The sound energy received by each individual animat over the 24-hr modeled period was also calculated as dB SPE and used as input to the risk continuum function to assess the potential risk of biologically significant behavioral reaction. To ensure that each individual is considered for only one potential impact (i.e., there is no double counting), the potential for PTS is considered first, as it represents the highest threshold. If an individual does not exceed the PTS threshold, then the potential for TTS is considered. If an animal does not exceed the TTS threshold, then the potential for a behavioral response is considered. Thus, individuals are not considered for more than one acoustic impact during a 24-hr exposure scenario.

The potential for PTS, TTS, and behavioral change has been estimated based on 24 hr of LFA sonar operations (Table 6-2). The potential for PTS (MMPA Level A) is considered within the context of the mitigation and monitoring efforts that will occur (Chapter 5). The NOAA (2016a) acoustic guidance for estimating the potential for PTS defines weighted thresholds as sound exposure levels (Table 6-1). The length of a nominal LFA transmission is 60 sec, which lowers the thresholds by approximately 18 dB SEL ($10x\log_{10}$ [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 the middle of the frequency range of LFA 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 $20\times\log_{10}$ [range in meters]), all functional hearing groups except LF cetaceans would need to be within 22 ft (7 m) for an entire LFA transmission (60 sec) to potentially experience PTS. An LF cetacean would need to be within 135 ft (41 m) for an entire LFA transmission to potentially experience PTS. Based on the mitigation procedures used during SURTASS LFA sonar operations, the chances of this occurring are negligible. Therefore, no PTS (MMPA Level A harassment) is expected with mitigation.

The percentage of marine mammal stocks that may experience TTS or behavioral changes from LFA sonar exposures was calculated for one season in each of the 26 mission areas. The noise exposure scenario was for a 24-hr period, with LFA sonar transmitting 60-sec signals every ten min for the entire period. Based on historical mission data, it is unlikely that such a scenario would occur, but it is a conservative method for estimating potential impacts. The Navy will limit operation of SURTASS LFA sonar to ensure that no more than 12 percent of any marine mammal stock would be taken by Level B harassment annually from transmissions of all SURTASS LFA sonar vessels. The Navy will use the 12 percent cap to guide its mission planning and selection of potential operational mission areas within each annual authorization application.

Table 6-2. Percentage of Marine Mammal Stocks Potentially Affected by 24 Hr of SURTASS LFA Sonar Transmissions Estimated for One Season in 26 Representative Mission Areas; Percent Stock Affected (With Mitigation Applied) at MMPA Level A Is 0.0000 Percent for all Marine Mammal Stocks in all Representative Mission Areas.

Marine Mammal Species	*Stock[12] Name*	*Stock Abundance*	*Percent Stock Affected—Behavioral Risk*	*Percent Stock Affected—TTS*	*Percent Stock Affected—Total Level B Harassment*
Mission Area 1: East of Japan; Summer Season					
Blue whale	WNP	9,250	₽[13]	₽[13]	₽[13]
Bryde's whale	WNP	20,501	0.0115%	0.0011%	0.0126%
Common minke whale	WNP "O"	25,049	0.0393%	0.0056%	0.0449%
Fin whale	WNP	9,250	0.0071%	0.0007%	0.0079%
Humpback whale	WNP stock and DPS[14]	1,328	0.0384%	0.0065%	0.0449%
North Pacific right whale	WNP	922	₽[13]	₽[13]	₽[13]
Sei whale	NP	7,000	0.0336%	0.0033%	0.0368%
Baird's beaked whale	WNP	8,000	0.1702%	0.0000%	0.1702%
Common bottlenose dolphin	WNP	168,791	0.0212%	0.0000%	0.0212%
Cuvier's beaked whale	WNP	90,725	0.0131%	0.0000%	0.0131%
False killer whale	WNP	16,668	0.0550%	0.0000%	0.0550%
Ginkgo-toothed beaked whale	NP	22,799	0.0084%	0.0000%	0.0084%
Harbor porpoise	WNP	31,046	0.0000%	0.0000%	0.0000%
Hubbs' beaked whale	NP	22,799	0.0084%	0.0000%	0.0084%
Killer whale	WNP	12,256	0.0030%	0.0000%	0.0030%
Kogia spp.	WNP	350,553	0.0032%	0.0000%	0.0032%
Pacific white-sided dolphin	NP	931,000	0.0010%	0.0000%	0.0010%
Pantropical spotted dolphin	WNP	438,064	0.0070%	0.0000%	0.0070%
Pygmy killer whale	WNP	30,214	0.0177%	0.0000%	0.0177%
Risso's dolphin	WNP	83,289	0.0405%	0.0000%	0.0405%
Rough-toothed dolphin	WNP	145,729	0.0139%	0.0000%	0.0139%
Short-beaked common dolphin	WNP	3,286,163	0.0078%	0.0000%	0.0078%
Short-finned pilot whale	WNP	53,608	0.0655%	0.0000%	0.0655%
Sperm whale	NP	102,112	0.0035%	0.0000%	0.0035%
Spinner dolphin	WNP	1,015,059	0.0001%	0.0000%	0.0001%
Stejneger's beaked whale	WNP	8,000	0.0240%	0.0000%	0.0240%
Striped dolphin	WNP	570,038	0.0023%	0.0000%	0.0023%
Mission Area 2: North Philippine Sea; Fall Season					
Blue whale	WNP	9,250	0.0004%	0.0001%	0.0005%
Bryde's whale	WNP	20,501	0.0115%	0.0033%	0.0149%

12 NP=North Pacific; EP=Eastern Pacific; WNP=Western North Pacific; CNP=Central North Pacific; ENP=Eastern North Pacific; WSP=Western South Pacific; ETP=Eastern Tropical Pacific; AK=Alaska; ECS=East China Sea; SOJ=Sea of Japan; IA=Inshore Archipelago; NMI=Northern Mariana Islands; C/O/W=California/Oregon/Washington; IND=Indian; NIND=Northern Indian; SIND=Southern Indian; WAU=Western Australia; AS=Arabian Sea; WNA=Western North Atlantic; ENA=Eastern North Atlantic; WM=Western Mediterranean

13 The ₽ symbol indicates that the marine mammal stock or DPS is not found in the mission area during the season modeled.

14 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 as stocks under the MMPA and as DPSs under the ESA. Thus, the humpback whale is listed by stock and DPS (DPS/stock) where relevant.

Table 6-2. Percentage of Marine Mammal Stocks Potentially Affected by 24 Hr of SURTASS LFA Sonar Transmissions Estimated for One Season in 26 Representative Mission Areas; Percent Stock Affected (With Mitigation Applied) at MMPA Level A Is 0.0000 Percent for all Marine Mammal Stocks in all Representative Mission Areas.

Marine Mammal Species	*Stock[12] Name*	*Stock Abundance*	*Percent Stock Affected—Behavioral Risk*	*Percent Stock Affected—TTS*	*Percent Stock Affected—Total Level B Harassment*
Common minke whale	WNP "O"	25,049	0.0632%	0.0165%	0.0798%
Fin whale	WNP	9,250	₽[13]	₽[13]	₽[13]
Humpback whale	WNP stock and DPS	1,328	0.2149%	0.0710%	0.2860%
North Pacific right whale	WNP	922	₽[13]	₽[13]	₽[13]
Omura's whale	WNP	1,800	0.0131%	0.0038%	0.0169%
Blainville's beaked whale	WNP	8,032	0.0220%	0.0000%	0.0220%
Common bottlenose dolphin	WNP	168,791	0.0203%	0.0000%	0.0203%
Cuvier's beaked whale	WNP	90,725	0.0210%	0.0000%	0.0210%
False killer whale	WNP	16,668	0.0434%	0.0000%	0.0434%
Fraser's dolphin	WNP	220,789	0.0084%	0.0000%	0.0084%
Ginkgo-toothed beaked whale	NP	22,799	0.0077%	0.0000%	0.0077%
Killer whale	WNP	12,256	0.0020%	0.0000%	0.0020%
Kogia spp.	WNP	350,553	0.0032%	0.0000%	0.0032%
Long-beaked common dolphin	WNP	279,182	0.1051%	0.0000%	0.1051%
Longman's beaked whale	WNP	4,571	0.0193%	0.0000%	0.0193%
Melon-headed whale	WNP	36,770	0.0290%	0.0000%	0.0290%
Pacific white-sided dolphin	NP	931,000	₽[13]	₽[13]	₽[13]
Pantropical spotted dolphin	WNP	438,064	0.0063%	0.0000%	0.0063%
Pygmy killer whale	WNP	30,214	0.0173%	0.0000%	0.0173%
Risso's dolphin	WNP	83,289	0.0445%	0.0000%	0.0445%
Rough-toothed dolphin	WNP	145,729	0.0138%	0.0000%	0.0138%
Short-beaked common dolphin	WNP	3,286,163	0.0043%	0.0000%	0.0043%
Short-finned pilot whale	WNP	53,608	0.0773%	0.0000%	0.0773%
Sperm whale	NP	102,112	0.0034%	0.0000%	0.0034%
Spinner dolphin	WNP	1,015,059	0.0002%	0.0000%	0.0002%
Striped dolphin	WNP	570,038	0.0115%	0.0000%	0.0115%
Mission Area 3: West Philippine Sea; Fall Season					
Blue whale	WNP	9,250	0.0005%	0.0002%	0.0007%
Bryde's whale	WNP	20,501	0.0121%	0.0051%	0.0172%
Common minke whale	WNP "O"	25,049	0.0501%	0.0250%	0.0752%
Fin whale	WNP	9,250	₽[13]	₽[13]	₽[13]
Humpback whale	WNP stock and DPS	1,328	0.2796%	0.1300%	0.4096%
Omura's whale	WNP	1,800	0.0138%	0.0058%	0.0196%
Blainville's beaked whale	WNP	8,032	0.0160%	0.0000%	0.0160%
Common bottlenose dolphin	WNP	168,791	0.0238%	0.0000%	0.0238%
Cuvier's beaked whale	WNP	90,725	0.0008%	0.0000%	0.0008%
Deraniyagala's beaked whale	NP	22,799	0.0056%	0.0000%	0.0056%
False killer whale	WNP	16,668	0.0487%	0.0000%	0.0487%

Table 6-2. Percentage of Marine Mammal Stocks Potentially Affected by 24 Hr of SURTASS LFA Sonar Transmissions Estimated for One Season in 26 Representative Mission Areas; Percent Stock Affected (With Mitigation Applied) at MMPA Level A Is 0.0000 Percent for all Marine Mammal Stocks in all Representative Mission Areas.

Marine Mammal Species	*Stock[12] Name*	*Stock Abundance*	*Percent Stock Affected—Behavioral Risk*	*Percent Stock Affected—TTS*	*Percent Stock Affected—Total Level B Harassment*
Fraser's dolphin	WNP	220,789	0.0084%	0.0000%	0.0084%
Ginkgo-toothed beaked whale	NP	22,799	0.0056%	0.0000%	0.0056%
Killer whale	WNP	12,256	0.0020%	0.0000%	0.0020%
Kogia spp.	WNP	350,553	0.0015%	0.0000%	0.0015%
Long-beaked common dolphin	WNP	279,182	0.1069%	0.0000%	0.1069%
Longman's beaked whale	WNP	4,571	0.0140%	0.0000%	0.0140%
Melon-headed whale	WNP	36,770	0.0326%	0.0000%	0.0326%
Pantropical spotted dolphin	WNP	438,064	0.0070%	0.0000%	0.0070%
Pygmy killer whale	WNP	30,214	0.0194%	0.0000%	0.0194%
Risso's dolphin	WNP	83,289	0.0394%	0.0000%	0.0394%
Rough-toothed dolphin	WNP	145,729	0.0120%	0.0000%	0.0120%
Short-finned pilot whale	WNP	53,608	0.0412%	0.0000%	0.0412%
Sperm whale	NP	102,112	0.0029%	0.0000%	0.0029%
Spinner dolphin	WNP	1,015,059	0.0002%	0.0000%	0.0002%
Striped dolphin	WNP	570,038	0.0065%	0.0000%	0.0065%
Mission Area 4: Offshore Guam; Summer Season					
Blue whale	WNP	9,250	₽[13]	₽[13]	₽[13]
Bryde's whale	WNP	20,501	0.0023%	0.0005%	0.0029%
Common minke whale	WNP "O"	25,049	₽[13]	₽[13]	₽[13]
Fin whale	WNP	9,250	₽[13]	₽[13]	₽[13]
Humpback whale	WNP stock and DPS	1,328	₽[13]	₽[13]	₽[13]
Omura's whale	WNP	1,800	0.0026%	0.0006%	0.0033%
Sei whale	NP	7,000	₽[13]	₽[13]	₽[13]
Blainville's beaked whale	WNP	8,032	0.0307%	0.0000%	0.0307%
Common bottlenose dolphin	WNP	168,791	0.0015%	0.0000%	0.0015%
Cuvier's beaked whale	WNP	90,725	0.0022%	0.0000%	0.0022%
Deraniyagala's beaked whale	NP	22,799	0.0105%	0.0000%	0.0105%
Dwarf sperm whale	WNP	350,553	0.0038%	0.0000%	0.0038%
False killer whale	WNP	16,668	0.0070%	0.0000%	0.0070%
Fraser's dolphin	CNP	16,992	0.0517%	0.0000%	0.0517%
Ginkgo-toothed beaked whale	NP	22,799	0.0077%	0.0000%	0.0077%
Killer whale	WNP	12,256	0.0012%	0.0000%	0.0012%
Longman's beaked whale	WNP	4,571	0.1052%	0.0000%	0.1052%
Melon-headed whale	NMI	2,455	0.1845%	0.0000%	0.1845%
Pantropical spotted dolphin	WNP	438,064	0.0031%	0.0000%	0.0031%
Pygmy killer whale	WNP	30,214	0.0005%	0.0000%	0.0005%
Pygmy sperm whale	WNP	350,553	0.0016%	0.0000%	0.0016%
Risso's dolphin	WNP	83,289	0.0071%	0.0000%	0.0071%
Rough-toothed dolphin	WNP	145,729	0.0031%	0.0000%	0.0031%
Short-finned pilot whale	WNP	53,608	0.0139%	0.0000%	0.0139%

Table 6-2. Percentage of Marine Mammal Stocks Potentially Affected by 24 Hr of SURTASS LFA Sonar Transmissions Estimated for One Season in 26 Representative Mission Areas; Percent Stock Affected (With Mitigation Applied) at MMPA Level A Is 0.0000 Percent for all Marine Mammal Stocks in all Representative Mission Areas.

Marine Mammal Species	*Stock[12] Name*	*Stock Abundance*	*Percent Stock Affected—Behavioral Risk*	*Percent Stock Affected—TTS*	*Percent Stock Affected—Total Level B Harassment*
Sperm whale	NP	102,112	0.0024%	0.0000%	0.0024%
Spinner dolphin	WNP	1,015,059	0.0000%	0.0000%	0.0000%
Striped dolphin	WNP	570,038	0.0006%	0.0000%	0.0006%
Mission Area 5: Sea of Japan; Fall Season					
Bryde’s whale	WNP	20,501	0.0023%	0.0002%	0.0025%
Common minke whale	WNP “O”	25,049	0.0071%	0.0005%	0.0076%
	WNP “J”	893	0.0800%	0.0054%	0.0854%
Fin whale	WNP	9,250	0.0789%	0.1024%	0.1812%
North Pacific right whale	WNP	922	₽[13]	₽[13]	₽[13]
Omura’s whale	WNP	1,800	0.0027%	0.0002%	0.0029%
Western North Pacific gray whale	WNP stock/ Western DPS	140	0.0090%	0.0023%	0.0113%
Baird’s beaked whale	WNP	8,000	0.0204%	0.0000%	0.0204%
Common bottlenose dolphin	IA	105,138	0.0020%	0.0000%	0.0020%
Cuvier’s beaked whale	WNP	90,725	0.0186%	0.0000%	0.0186%
Dall’s porpoise	SOJ	173,638	0.0290%	0.0000%	0.0290%
False killer whale	IA	9,777	0.0806%	0.0000%	0.0806%
Harbor porpoise	WNP	31,046	0.0418%	0.0000%	0.0418%
Killer whale	WNP	12,256	0.0029%	0.0000%	0.0029%
Kogia spp.	WNP	350,553	0.0022%	0.0000%	0.0022%
Long-beaked common dolphin	WNP	279,182	0.1374%	0.0000%	0.1374%
Pacific white-sided dolphin	NP	931,000	₽[13]	₽[13]	₽[13]
Risso’s dolphin	IA	83,289	0.0394%	0.0000%	0.0394%
Rough-toothed dolphin	WNP	145,729	0.0079%	0.0000%	0.0079%
Short-beaked common dolphin	WNP	3,286,163	0.0087%	0.0000%	0.0087%
Short-finned pilot whale	WNP	53,608	0.0097%	0.0000%	0.0097%
Sperm whale	NP	102,112	0.0092%	0.0000%	0.0092%
Spinner dolphin	WNP	1,015,059	0.0001%	0.0000%	0.0001%
Stejneger’s beaked whale	WNP	8,000	0.0232%	0.0000%	0.0232%
Striped dolphin	IA	570,038	0.0011%	0.0000%	0.0011%
Spotted seal	Southern stock and DPS	3,500	0.0002%	0.0000%	0.0002%
Mission Area 6: East China Sea; Summer Season					
Bryde’s whale	ECS	137	0.6723%	0.7883%	1.4606%
Common minke whale	WNP “O”	25,049	0.0459%	0.0646%	0.1105%
	WNP “J”	893	0.5263%	0.7418%	1.2681%
Fin whale	ECS	500	0.1091%	0.1336%	0.2427%
North Pacific right whale	WNP	922	₽[13]	₽[13]	₽[13]
Omura’s whale	WNP	1,800	0.0051%	0.0060%	0.0111%
Western North Pacific gray	WNP stock/	140	₽[13]	₽[13]	₽[13]

Table 6-2. Percentage of Marine Mammal Stocks Potentially Affected by 24 Hr of SURTASS LFA Sonar Transmissions Estimated for One Season in 26 Representative Mission Areas; Percent Stock Affected (With Mitigation Applied) at MMPA Level A Is 0.0000 Percent for all Marine Mammal Stocks in all Representative Mission Areas.

Marine Mammal Species	*Stock[12] Name*	*Stock Abundance*	*Percent Stock Affected—Behavioral Risk*	*Percent Stock Affected—TTS*	*Percent Stock Affected—Total Level B Harassment*
whale	Western DPS				
Blainville's beaked whale	WNP	8,032	0.0222%	0.0000%	0.0222%
Common bottlenose dolphin	IA	105,138	0.0038%	0.0000%	0.0038%
Cuvier's beaked whale	WNP	90,725	0.0012%	0.0000%	0.0012%
False killer whale	IA	9,777	0.0345%	0.0000%	0.0345%
Fraser's dolphin	WNP	220,789	0.0116%	0.0000%	0.0116%
Ginkgo-toothed beaked whale	NP	22,799	0.0078%	0.0000%	0.0078%
Killer whale	WNP	12,256	0.0023%	0.0000%	0.0023%
Kogia spp.	WNP	350,553	0.0017%	0.0000%	0.0017%
Long-beaked common dolphin	WNP	279,182	0.1258%	0.0000%	0.1258%
Longman's beaked whale	WNP	4,571	0.0195%	0.0000%	0.0195%
Melon-headed whale	WNP	36,770	0.0354%	0.0000%	0.0354%
Pacific white-sided dolphin	NP	931,000	₽[13]	₽[13]	₽[13]
Pantropical spotted dolphin	WNP	219,032	0.0163%	0.0000%	0.0163%
Pygmy killer whale	WNP	30,214	0.0014%	0.0000%	0.0014%
Risso's dolphin	IA	83,289	0.0517%	0.0000%	0.0517%
Rough-toothed dolphin	WNP	145,729	0.0066%	0.0000%	0.0066%
Short-beaked common dolphin	WNP	3,286,163	0.0043%	0.0000%	0.0043%
Short-finned pilot whale	WNP	53,608	0.0102%	0.0000%	0.0102%
Sperm whale	NP	102,112	0.0035%	0.0000%	0.0035%
Spinner dolphin	WNP	1,015,059	0.0002%	0.0000%	0.0002%
Striped dolphin	IA	570,038	0.0027%	0.0000%	0.0027%
Spotted seal	Southern stock and DPS	1,000	0.0025%	0.0001%	0.0027%
Mission Area 7: South China Sea; Fall Season					
Bryde's whale	WNP	20,501	0.0084%	0.0006%	0.0090%
Common minke whale	WNP "O"	25,049	0.0387%	0.0032%	0.0419%
	WNP "J"	893	0.5924%	0.0484%	0.6407%
Fin whale	WNP	9,250	0.0049%	0.0009%	0.0058%
Humpback whale	WNP stock and DPS	1,328	0.0434%	0.0038%	0.0472%
North Pacific right whale	WNP	922	₽[13]	₽[13]	₽[13]
Omura's whale	WNP	1,800	0.0096%	0.0007%	0.0103%
Western North Pacific gray whale	WNP stock/ Western DPS	140	0.0117%	0.0019%	0.0136%
Blainville's beaked whale	WNP	8,032	0.0134%	0.0000%	0.0134%
Common bottlenose dolphin	IA	105,138	0.0012%	0.0000%	0.0012%
Cuvier's beaked whale	WNP	90,725	0.0007%	0.0000%	0.0007%
Deraniyagala's beaked whale	NP	22,799	0.0047%	0.0000%	0.0047%
False killer whale	IA	9,777	0.0204%	0.0000%	0.0204%

Table 6-2. Percentage of Marine Mammal Stocks Potentially Affected by 24 Hr of SURTASS LFA Sonar Transmissions Estimated for One Season in 26 Representative Mission Areas; Percent Stock Affected (With Mitigation Applied) at MMPA Level A Is 0.0000 Percent for all Marine Mammal Stocks in all Representative Mission Areas.

Marine Mammal Species	***Stock[12] Name***	***Stock Abundance***	***Percent Stock Affected—Behavioral Risk***	***Percent Stock Affected—TTS***	***Percent Stock Affected—Total Level B Harassment***
Fraser's dolphin	WNP	220,789	0.0063%	0.0000%	0.0063%
Ginkgo-toothed beaked whale	NP	22,799	0.0047%	0.0000%	0.0047%
Killer whale	WNP	12,256	0.0017%	0.0000%	0.0017%
Kogia spp.	WNP	350,553	0.0012%	0.0000%	0.0012%
Long-beaked common dolphin	WNP	279,182	0.0850%	0.0000%	0.0850%
Longman's beaked whale	WNP	4,571	0.0118%	0.0000%	0.0118%
Melon-headed whale	WNP	36,770	0.0209%	0.0000%	0.0209%
Pantropical spotted dolphin	WNP	219,032	0.0063%	0.0000%	0.0063%
Pygmy killer whale	WNP	30,214	0.0008%	0.0000%	0.0008%
Risso's dolphin	IA	83,289	0.0304%	0.0000%	0.0304%
Rough-toothed dolphin	WNP	145,729	0.0043%	0.0000%	0.0043%
Short-finned pilot whale	WNP	53,608	0.0051%	0.0000%	0.0051%
Sperm whale	NP	102,112	0.0023%	0.0000%	0.0023%
Spinner dolphin	WNP	1,015,059	0.0001%	0.0000%	0.0001%
Striped dolphin	IA	570,038	0.0010%	0.0000%	0.0010%
Mission Area 8: Offshore Japan 25° to 40°N; Summer Season					
Blue whale	WNP	9,250	₽[13]	₽[13]	₽[13]
Bryde's whale	WNP	20,501	0.0123%	0.0032%	0.0155%
Common minke whale	WNP "O"	25,049	0.0102%	0.0018%	0.0121%
Fin whale	WNP	9,250	0.0117%	0.0028%	0.0145%
Humpback whale	WNP stock and DPS	1,328	0.2480%	0.1111%	0.3591%
Sei whale	NP	7,000	0.0255%	0.0066%	0.0322%
Baird's beaked whale	WNP	8,000	0.0044%	0.0000%	0.0044%
Blainville's beaked whale	WNP	8,032	0.0217%	0.0000%	0.0217%
Common bottlenose dolphin	WNP	168,791	0.0016%	0.0000%	0.0016%
Cuvier's beaked whale	WNP	90,725	0.0103%	0.0000%	0.0103%
Dwarf sperm whale	WNP	350,553	0.0053%	0.0000%	0.0053%
False killer whale	WNP	16,668	0.0865%	0.0000%	0.0865%
Hubbs' beaked whale	NP	22,799	0.0055%	0.0000%	0.0055%
Killer whale	WNP	12,256	0.0029%	0.0000%	0.0029%
Longman's beaked whale	WNP	4,571	0.0164%	0.0000%	0.0164%
Melon-headed whale	WNP	36,770	0.0294%	0.0000%	0.0294%
Mesoplodon spp.	WNP	22,799	0.0055%	0.0000%	0.0055%
Northern right whale dolphin	NP	68,000	₽[13]	₽[13]	₽[13]
Pacific white-sided dolphin	NP	931,000	0.0014%	0.0000%	0.0014%
Pantropical spotted dolphin	WNP	438,064	0.0076%	0.0000%	0.0076%
Pygmy killer whale	WNP	30,214	0.0013%	0.0000%	0.0013%
Pygmy sperm whale	WNP	350,553	0.0022%	0.0000%	0.0022%
Risso's dolphin	WNP	83,289	0.0023%	0.0000%	0.0023%
Rough-toothed dolphin	WNP	145,729	0.0040%	0.0000%	0.0040%

Table 6-2. Percentage of Marine Mammal Stocks Potentially Affected by 24 Hr of SURTASS LFA Sonar Transmissions Estimated for One Season in 26 Representative Mission Areas; Percent Stock Affected (With Mitigation Applied) at MMPA Level A Is 0.0000 Percent for all Marine Mammal Stocks in all Representative Mission Areas.

Marine Mammal Species	*Stock[12] Name*	*Stock Abundance*	*Percent Stock Affected—Behavioral Risk*	*Percent Stock Affected—TTS*	*Percent Stock Affected—Total Level B Harassment*
Short-beaked common dolphin	WNP	3,286,163	0.0123%	0.0000%	0.0123%
Short-finned pilot whale	WNP	53,608	0.0199%	0.0000%	0.0199%
Sperm whale	NP	102,112	0.0044%	0.0000%	0.0044%
Spinner dolphin	WNP	1,015,059	0.0006%	0.0000%	0.0006%
Stejneger's beaked whale	WNP	8,000	0.0156%	0.0000%	0.0156%
Striped dolphin	WNP	570,038	0.0030%	0.0000%	0.0030%
Hawaiian monk seal	Hawaii	1,112	0.0518%	0.0011%	0.0518%
Northern fur seal	Western Pacific	503,609	₽[13]	₽[13]	₽[13]
Mission Area 9: Offshore Japan 10° to 25°N; Winter Season					
Blue whale	WNP	9,250	0.0004%	0.0003%	0.0007%
Bryde's whale	WNP	20,501	0.0061%	0.0051%	0.0112%
Fin whale	WNP	9,250	0.0004%	0.0003%	0.0007%
Humpback whale	WNP stock and DPS	1,328	0.1006%	0.1063%	0.2069%
Omura's whale	WNP	1,800	0.0070%	0.0058%	0.0128%
Sei whale	NP	7,000	0.1729%	0.1442%	0.3171%
Blainville's beaked whale	WNP	8,032	0.0175%	0.0000%	0.0175%
Common bottlenose dolphin	WNP	168,791	0.0013%	0.0000%	0.0013%
Cuvier's beaked whale	WNP	90,725	0.0083%	0.0000%	0.0083%
Deraniyagala's beaked whale	NP	22,799	0.0082%	0.0000%	0.0082%
Dwarf sperm whale	WNP	350,553	0.0034%	0.0000%	0.0034%
False killer whale	WNP	16,668	0.0100%	0.0000%	0.0100%
Fraser's dolphin	CNP	16,992	0.0433%	0.0000%	0.0433%
Ginkgo-toothed beaked whale	NP	22,799	0.0082%	0.0000%	0.0082%
Killer whale	WNP	12,256	0.0021%	0.0000%	0.0021%
Longman's beaked whale	WNP	4,571	0.0110%	0.0000%	0.0110%
Melon-headed whale	WNP	36,770	0.0208%	0.0000%	0.0208%
Pantropical spotted dolphin	WNP	438,064	0.0072%	0.0000%	0.0072%
Pygmy killer whale	WNP	30,214	0.0006%	0.0000%	0.0006%
Pygmy sperm whale	WNP	350,553	0.0014%	0.0000%	0.0014%
Risso's dolphin	WNP	83,289	0.0016%	0.0000%	0.0016%
Rough-toothed dolphin	WNP	145,729	0.0036%	0.0000%	0.0036%
Short-finned pilot whale	WNP	53,608	0.0107%	0.0000%	0.0107%
Sperm whale	NP	102,112	0.0046%	0.0000%	0.0046%
Spinner dolphin	WNP	1,015,059	0.0005%	0.0000%	0.0005%
Striped dolphin	WNP	570,038	0.0029%	0.0000%	0.0029%
Mission Area 10: Hawaii North; Summer Season					
Blue whale	CNP	81	₽[13]	₽[13]	₽[13]
Bryde's whale	Hawaii	798	0.1557%	0.0286%	0.1843%
Common minke whale	Hawaii	25,049	₽[13]	₽[13]	₽[13]

Table 6-2. Percentage of Marine Mammal Stocks Potentially Affected by 24 Hr of SURTASS LFA Sonar Transmissions Estimated for One Season in 26 Representative Mission Areas; Percent Stock Affected (With Mitigation Applied) at MMPA Level A Is 0.0000 Percent for all Marine Mammal Stocks in all Representative Mission Areas.

Marine Mammal Species	*Stock[12] Name*	*Stock Abundance*	*Percent Stock Affected—Behavioral Risk*	*Percent Stock Affected—TTS*	*Percent Stock Affected—Total Level B Harassment*
Fin whale	Hawaii	58	₽[13]	₽[13]	₽[13]
Humpback whale	Central stock/ Hawaii DPS	10,103	₽[13]	₽[13]	₽[13]
Sei whale	Hawaii	178	₽[13]	₽[13]	₽[13]
Blainville's beaked whale	Hawaii	2,338	0.1094%	0.0000%	0.1094%
Common bottlenose dolphin	Hawaii Pelagic	5,950	0.1005%	0.0000%	0.1005%
	Kauai/Niihau	184	0.0001%	0.0000%	0.0001%
	4-Islands	191	0.0000%	0.0000%	0.0000%
	Oahu	743	0.0000%	0.0000%	0.0000%
	Hawaii Island	128	0.0000%	0.0000%	0.0000%
Cuvier's beaked whale	Hawaii	1,941	0.1054%	0.0000%	0.1054%
Dwarf sperm whale	Hawaii	17,519	0.1299%	0.0000%	0.1299%
False killer whale	Hawaii Pelagic	1,540	0.1053%	0.0000%	0.1053%
	Main Hawaiian Islands Insular stock and DPS	151	0.0134%	0.0000%	0.0134%
	Northwestern Hawaiian Islands	617	0.0026%	0.0000%	0.0026%
Fraser's dolphin	Hawaii	16,992	0.1298%	0.0000%	0.1298%
Killer whale	Hawaii	101	0.1422%	0.0000%	0.1422%
Longman's beaked whale	Hawaii	4,571	0.1063%	0.0000%	0.1063%
Melon-headed whale	Hawaiian Islands	5,794	0.0560%	0.0000%	0.0560%
	Kohala Resident	447	0.0000%	0.0000%	0.0000%
Pantropical spotted dolphin	Hawaiian Pelagic	15,917	0.0788%	0.0000%	0.0788%
	Hawaii Island	220	0.0000%	0.0000%	0.0000%
	Oahu	220	0.0000%	0.0000%	0.0000%
	4-Islands	220	0.0000%	0.0000%	0.0000%
Pygmy killer whale	Hawaii	3,433	0.1102%	0.0000%	0.1102%
Pygmy sperm whale	Hawaii	7,138	0.1295%	0.0000%	0.1295%
Risso's dolphin	Hawaii	7,256	0.1277%	0.0000%	0.1277%
Rough-toothed dolphin	Hawaii	6,288	0.1436%	0.0000%	0.1436%
Short-finned pilot whale	Hawaii	12,422	0.1129%	0.0000%	0.1129%
Sperm whale	Hawaii	3,354	0.0995%	0.0000%	0.0995%
Spinner dolphin	Hawaii Pelagic	3,351	0.0447%	0.0000%	0.0447%
	Kauai/Niihau	601	0.0013%	0.0000%	0.0013%
	Hawaii Island	631	0.0000%	0.0000%	0.0000%
	Oahu/4-Islands	355	0.0000%	0.0000%	0.0000%
	Kure/Midway Atoll	260	0.0000%	0.0000%	0.0000%

Table 6-2. Percentage of Marine Mammal Stocks Potentially Affected by 24 Hr of SURTASS LFA Sonar Transmissions Estimated for One Season in 26 Representative Mission Areas; Percent Stock Affected (With Mitigation Applied) at MMPA Level A Is 0.0000 Percent for all Marine Mammal Stocks in all Representative Mission Areas.

Marine Mammal Species	*Stock[12] Name*	*Stock Abundance*	*Percent Stock Affected—Behavioral Risk*	*Percent Stock Affected—TTS*	*Percent Stock Affected—Total Level B Harassment*
	Pearl and Hermes Reef	300	0.0000%	0.0000%	0.0000%
Striped dolphin	Hawaii	20,650	0.0762%	0.0000%	0.0762%
Hawaiian monk seal	Hawaii	1,112	0.0023%	0.0001%	0.0023%
Mission Area 11: Hawaii South; Fall Season					
Blue whale	CNP	81	0.1105%	0.0832%	0.1937%
Bryde's whale	Hawaii	798	0.1030%	0.0749%	0.1779%
Common minke whale	Hawaii	25,049	0.0023%	0.0016%	0.0040%
Fin whale	Hawaii	58	0.0968%	0.0648%	0.1616%
Humpback whale	Central stock/ Hawaii DPS	10,103	0.0209%	0.0155%	0.0364%
Sei whale	Hawaii	178	0.1539%	0.1120%	0.2659%
Blainville's beaked whale	Hawaii	2,338	0.0919%	0.0000%	0.0919%
Common bottlenose dolphin	Hawaii Pelagic	5,950	0.0922%	0.0000%	0.0922%
	Kauai/Niihau	184	0.0000%	0.0000%	0.0000%
	4-Islands	191	0.0001%	0.0000%	0.0001%
	Oahu	743	0.0007%	0.0000%	0.0007%
	Hawaii Island	128	0.0000%	0.0000%	0.0000%
Cuvier's beaked whale	Hawaii	1,941	0.0886%	0.0000%	0.0886%
Deraniyagala beaked whale	NP	22,799	0.0088%	0.0000%	0.0088%
Dwarf sperm whale	Hawaii	17,519	0.1072%	0.0000%	0.1072%
False killer whale	Hawaii Pelagic	1,540	0.0933%	0.0000%	0.0933%
	Main Hawaiian Islands Insular stock and DPS	151	0.0562%	0.0000%	0.0562%
Fraser's dolphin	Hawaii	16,992	0.1051%	0.0000%	0.1051%
Killer whale	Hawaii	101	0.1125%	0.0000%	0.1125%
Longman's beaked whale	Hawaii	4,571	0.0893%	0.0000%	0.0893%
Melon-headed whale	Hawaiian Islands	5,794	0.0496%	0.0000%	0.0496%
	Kohala Resident	447	0.0112%	0.0000%	0.0112%
Pantropical spotted dolphin	Hawaiian Pelagic	15,917	0.0808%	0.0000%	0.0808%
	Hawaii Island	220	0.1293%	0.0000%	0.1293%
	Oahu	220	0.1027%	0.0000%	0.1027%
	4-Islands	220	0.1438%	0.0000%	0.1438%
Pygmy killer whale	Hawaii	3,433	0.0976%	0.0000%	0.0976%
Pygmy sperm whale	Hawaii	7,138	0.1068%	0.0000%	0.1068%
Risso's dolphin	Hawaii	7,256	0.1025%	0.0000%	0.1025%
Rough-toothed dolphin	Hawaii	6,288	0.1050%	0.0000%	0.1050%
Short-finned pilot whale	Hawaii	12,422	0.0965%	0.0000%	0.0965%

Table 6-2. Percentage of Marine Mammal Stocks Potentially Affected by 24 Hr of SURTASS LFA Sonar Transmissions Estimated for One Season in 26 Representative Mission Areas; Percent Stock Affected (With Mitigation Applied) at MMPA Level A Is 0.0000 Percent for all Marine Mammal Stocks in all Representative Mission Areas.

Marine Mammal Species	*Stock[12] Name*	*Stock Abundance*	*Percent Stock Affected—Behavioral Risk*	*Percent Stock Affected—TTS*	*Percent Stock Affected—Total Level B Harassment*
Sperm whale	Hawaii	3,354	0.0799%	0.0000%	0.0799%
Spinner dolphin	Hawaii Pelagic	3,351	0.0458%	0.0000%	0.0458%
	Kauai/Niihau	601	0.0000%	0.0000%	0.0000%
	Hawaii Island	631	0.0016%	0.0000%	0.0016%
	Oahu/4-Islands	355	0.1613%	0.0000%	0.1613%
Striped dolphin	Hawaii	20,650	0.0781%	0.0000%	0.0781%
Hawaiian monk seal	Hawaii	1,112	0.0032%	0.0002%	0.0032%
Mission Area 12: Offshore Southern California; Spring Season					
Blue whale	ENP	1,647	0.0105%	0.0017%	0.0122%
Bryde's whale	ENP	13,000	0.0002%	0.0000%	0.0002%
Common minke whale	C/O/W	478	0.1364%	0.0143%	0.1508%
Eastern North Pacific gray whale	ENP	20,990	0.0318%	0.0000%	0.0318%
Fin whale	C/O/W	3,051	0.0084%	0.0017%	0.0101%
Humpback whale	C/O/W stock/ Mexico DPS	1,918	0.0084%	0.0151%	0.0235%
Sei whale	ENP	126	0.1646%	0.0271%	0.1918%
Western North Pacific gray whale	WNP stock/ Western DPS	140	0.0015%	0.0000%	0.0015%
Baird's beaked whale	C/O/W	847	0.2260%	0.0000%	0.2260%
Blainville's beaked whale	C/O/W	694	0.3495%	0.0000%	0.3495%
Common bottlenose dolphin	C/O/W	1,006	1.5987%	0.0000%	1.5987%
Cuvier's beaked whale	C/O/W	6,590	0.1318%	0.0000%	0.1318%
Dall's porpoise	C/O/W	42,000	0.1760%	0.0000%	0.1760%
Ginkgo-toothed beaked whale	C/O/W	694	0.0699%	0.0000%	0.0699%
Hubb's beaked whale	C/O/W	694	0.3145%	0.0000%	0.3145%
Killer whale	Eastern Pacific Offshore	240	0.3130%	0.0000%	0.3130%
Long-beaked common dolphin	California	107,016	0.1687%	0.0000%	0.1687%
Northern right whale dolphin	C/O/W	21,332	2.2343%	0.0000%	2.2343%
Pacific white-sided dolphin	C/O/W (Northern and Southern)	26,930	0.9424%	0.0000%	0.9424%
Perrin's beaked whale	C/O/W	694	0.3145%	0.0000%	0.3145%
Pygmy beaked whale	C/O/W	694	0.0699%	0.0000%	0.0699%
Pygmy sperm whale	C/O/W	579	0.4494%	0.0000%	0.4494%
Risso's dolphin	C/O/W	6,272	0.3804%	0.0000%	0.3804%
Short-beaked common dolphin	C/O/W	411,211	0.4863%	0.0000%	0.4863%
Short-finned pilot whale	C/O/W	760	0.0595%	0.0000%	0.0595%
Sperm whale	C/O/W	2,106	0.3340%	0.0000%	0.3340%

Table 6-2. Percentage of Marine Mammal Stocks Potentially Affected by 24 Hr of SURTASS LFA Sonar Transmissions Estimated for One Season in 26 Representative Mission Areas; Percent Stock Affected (With Mitigation Applied) at MMPA Level A Is 0.0000 Percent for all Marine Mammal Stocks in all Representative Mission Areas.

Marine Mammal Species	***Stock[12] Name***	***Stock Abundance***	***Percent Stock Affected—Behavioral Risk***	***Percent Stock Affected—TTS***	***Percent Stock Affected—Total Level B Harassment***
Stejneger's beaked whale	C/O/W	694	0.2097%	0.0000%	0.2097%
Striped dolphin	C/O/W	10,908	0.1136%	0.0000%	0.1136%
California sea lion	U.S. (Pacific Temperate)	296,750	0.0013%	0.0000%	0.0013%
Guadalupe fur seal	Mexico	7,408	0.0553%	0.0000%	0.0553%
Harbor seal	California	30,968	0.0852%	0.0066%	0.0918%
Northern elephant seal	California Breeding	179,000	0.0002%	0.0000%	0.0002%
Northern fur seal	California	14,050	0.1340%	0.0000%	0.1340%
Mission Area 13: Western North Atlantic (off Florida); Winter Season					
Common minke whale	Canadian East Coast	20,741	0.0451%	0.0583%	0.1034%
Humpback whale	Gulf of Maine stock/West Indies DPS	12,312	0.0015%	0.0026%	0.0041%
North Atlantic right whale	WNA	476	0.0243%	0.0229%	0.0405%
Atlantic spotted dolphin	WNA	44,715	0.0937%	0.0000%	0.0937%
Clymene dolphin	WNA	6,086	1.5192%	0.0000%	1.5192%
Common bottlenose dolphin	Offshore WNA	77,532	0.1781%	0.0000%	0.1781%
	Southern Migratory Coast	9,173	0.0000%	0.0000%	0.0000%
	Northern Florida Coast	1,219	0.0000%	0.0000%	0.0000%
	Central Florida Coast	4,895	0.0000%	0.0000%	0.0000%
Cuvier’s beaked whale	WNA	6,532	0.0682%	0.0000%	0.0682%
False killer whale	WNA	442	0.0623%	0.0000%	0.0623%
Killer whale	WNA	67	0.0475%	0.0000%	0.0475%
Kogia spp.	WNA	3,785	0.0836%	0.0000%	0.0836%
Mesoplodon spp.	WNA	7,092	0.0681%	0.0000%	0.0681%
Pantropical spotted dolphin	WNA	3,333	0.6688%	0.0000%	0.6688%
Risso’s dolphin	WNA	18,250	0.0750%	0.0000%	0.0750%
Rough-toothed dolphin	WNA	271	0.8154%	0.0000%	0.8154%
Short-beaked common dolphin	WNA	173,486	0.0022%	0.0000%	0.0022%
Short-finned pilot whale	WNA	21,515	0.1034%	0.0000%	0.1034%
Sperm whale	WNA	2,288	0.0903%	0.0000%	0.0903%
Spinner dolphin	WNA	262	0.5597%	0.0000%	0.5597%
Striped dolphin	WNA	54,807	0.0199%	0.0000%	0.0199%
Mission Area 14: Eastern North Atlantic; Summer Season					
Blue whale	ENA	979	0.0219%	0.1729%	0.1948%

Table 6-2. Percentage of Marine Mammal Stocks Potentially Affected by 24 Hr of SURTASS LFA Sonar Transmissions Estimated for One Season in 26 Representative Mission Areas; Percent Stock Affected (With Mitigation Applied) at MMPA Level A Is 0.0000 Percent for all Marine Mammal Stocks in all Representative Mission Areas.

Marine Mammal Species	*Stock[12] Name*	*Stock Abundance*	*Percent Stock Affected—Behavioral Risk*	*Percent Stock Affected—TTS*	*Percent Stock Affected—Total Level B Harassment*
Common minke whale	Northeast Atlantic	78,572	0.0516%	0.2664%	0.3180%
Fin whale	ENA	9,019	0.1355%	1.5374%	1.6729%
Humpback whale	Iceland stock/Cape Verdes and West Africa DPS	11,572	0.0017%	0.0141%	0.0157%
Sei whale	Iceland-Denmark Strait	10,300	0.0487%	0.2385%	0.2872%
Atlantic white-sided dolphin	ENA	3,904	0.0024%	0.0000%	0.0024%
Blainville's beaked whale	ENA	6,992	1.0967%	0.0000%	1.0967%
Common bottlenose dolphin	ENA	35,780	0.1025%	0.0000%	0.1025%
Cuvier's beaked whale	ENA	6,992	1.0967%	0.0000%	1.0967%
Gervais' beaked whale	ENA	6,992	1.0967%	0.0000%	1.0967%
Harbor porpoise	ENA	375,358	0.1602%	0.0000%	0.1602%
Killer whale	Northern Norway	731	0.0364%	0.0000%	0.0364%
Kogia spp.	ENA	3,785	0.3575%	0.0000%	0.3575%
Long-finned pilot whale	ENA	128,093	0.7065%	0.0000%	0.7065%
Northern bottlenose whale	ENA	19,538	0.2533%	0.0000%	0.2533%
Risso's dolphin	ENA	18,250	0.1943%	0.0000%	0.1943%
Short-beaked common dolphin	ENA	172,930	0.1426%	0.0000%	0.1426%
Sowerby's beaked whale	ENA	6,992	1.0967%	0.0000%	1.0967%
Sperm whale	ENA	7,785	0.0837%	0.0000%	0.0837%
Striped dolphin	ENA	67,414	0.0198%	0.0000%	0.0198%
True's beaked whale	ENA	6,992	1.0967%	0.0000%	1.0967%
White-beaked dolphin	ENA	16,536	0.7899%	0.0000%	0.7899%
Gray seal	Northwest Europe	116,800	0.0050%	0.0000%	0.0050%
Harbor seal	Northwest Europe	40,414	1.0046%	0.0000%	1.0046%
Mission Area 15: Mediterranean Sea; Summer Season					
Fin whale	Mediterranean	3,583	0.7794%	0.9256%	1.7050%
Common bottlenose dolphin	WM	1,676	0.6764%	0.0000%	0.6764%
Cuvier's beaked whale	Alboran Sea	429	0.3687%	0.0000%	0.3687%
Long-finned pilot whale	ENA	21,515	0.2394%	0.0000%	0.2394%
Risso's dolphin	WM	5,320	0.5147%	0.0000%	0.5147%
Short-beaked common dolphin	WM	19,428	0.2334%	0.0000%	0.2334%
Sperm whale	WM	396	1.4879%	0.0000%	1.4879%

Table 6-2. Percentage of Marine Mammal Stocks Potentially Affected by 24 Hr of SURTASS LFA Sonar Transmissions Estimated for One Season in 26 Representative Mission Areas; Percent Stock Affected (With Mitigation Applied) at MMPA Level A Is 0.0000 Percent for all Marine Mammal Stocks in all Representative Mission Areas.

Marine Mammal Species	*Stock[12] Name*	*Stock Abundance*	*Percent Stock Affected—Behavioral Risk*	*Percent Stock Affected—TTS*	*Percent Stock Affected—Total Level B Harassment*
Striped dolphin	WM	117,880	0.3756%	0.0000%	0.3756%
Mission Area 16: Arabian Sea; Summer Season					
Blue whale	NIND	3,432	0.0043%	0.0010%	0.0053%
Bryde's whale	NIND	9,176	0.0170%	0.0031%	0.0201%
Common minke whale	IND	257,500	0.0149%	0.0034%	0.0182%
Fin whale	IND	1,716	0.1652%	0.0332%	0.1985%
Humpback whale	AS stock and DPS	200	0.0620%	0.0100%	0.0720%
Blainville's beaked whale	IND	16,867	0.0443%	0.0000%	0.0443%
Common bottlenose dolphin	IND	785,585	0.0133%	0.0000%	0.0133%
Cuvier's beaked whale	IND	27,272	0.0306%	0.0000%	0.0306%
Deraniyagala beaked whale	IND	16,867	0.0446%	0.0000%	0.0446%
Dwarf sperm whale	IND	10,541	0.0016%	0.0000%	0.0016%
False killer whale	IND	144,188	0.0004%	0.0000%	0.0004%
Fraser's dolphin	IND	151,554	0.0035%	0.0000%	0.0035%
Ginkgo-toothed beaked whale	IND	16,867	0.0446%	0.0000%	0.0446%
Indo-Pacific bottlenose dolphin	IND	7,850	0.0133%	0.0000%	0.0133%
Killer whale	IND	12,593	0.1890%	0.0000%	0.1890%
Long-beaked common dolphin	IND	1,819,882	0.0000%	0.0000%	0.0000%
Longman's beaked whale	IND	16,867	0.1914%	0.0000%	0.1914%
Melon-headed whale	IND	64,600	0.0338%	0.0000%	0.0338%
Pantropical spotted dolphin	IND	736,575	0.0016%	0.0000%	0.0016%
Pygmy killer whale	IND	22,029	0.0150%	0.0000%	0.0150%
Pygmy sperm whale	IND	10,541	0.0005%	0.0000%	0.0005%
Risso's dolphin	IND	452,125	0.0542%	0.0000%	0.0542%
Rough-toothed dolphin	IND	156,690	0.0013%	0.0000%	0.0013%
Short-finned pilot whale	IND	268,751	0.0302%	0.0000%	0.0302%
Sperm whale	NIND	24,446	0.0841%	0.0000%	0.0841%
Spinner dolphin	IND	634,108	0.0015%	0.0000%	0.0015%
Striped dolphin	IND	674,578	0.0294%	0.0000%	0.0294%
Mission Area 17: Andaman Sea; Summer Season					
Blue whale	NIND	3,432	0.0006%	0.0003%	0.0009%
Bryde's whale	NIND	9,176	0.0038%	0.0038%	0.0076%
Common minke whale	IND	257,500	0.0026%	0.0019%	0.0045%
Fin whale	IND	1,716	₽[13]	₽[13]	₽[13]
Omura's whale	IND	9,176	0.0038%	0.0038%	0.0076%
Blainville's beaked whale	IND	16,867	0.0094%	0.0000%	0.0094%
Common bottlenose dolphin	IND	785,585	0.0084%	0.0000%	0.0084%
Cuvier's beaked whale	IND	27,272	0.0297%	0.0000%	0.0297%
Deraniyagala beaked whale	IND	16,867	0.0097%	0.0000%	0.0097%

Table 6-2. Percentage of Marine Mammal Stocks Potentially Affected by 24 Hr of SURTASS LFA Sonar Transmissions Estimated for One Season in 26 Representative Mission Areas; Percent Stock Affected (With Mitigation Applied) at MMPA Level A Is 0.0000 Percent for all Marine Mammal Stocks in all Representative Mission Areas.

Marine Mammal Species	*Stock[12] Name*	*Stock Abundance*	*Percent Stock Affected—Behavioral Risk*	*Percent Stock Affected—TTS*	*Percent Stock Affected—Total Level B Harassment*
Dwarf sperm whale	IND	10,541	0.0008%	0.0000%	0.0008%
False killer whale	IND	144,188	0.0002%	0.0000%	0.0002%
Fraser's dolphin	IND	151,554	0.0016%	0.0000%	0.0016%
Ginkgo-toothed beaked whale	IND	16,867	0.0097%	0.0000%	0.0097%
Indo-Pacific bottlenose dolphin	IND	7,850	0.0157%	0.0000%	0.0157%
Killer whale	IND	12,593	0.0691%	0.0000%	0.0691%
Long-beaked common dolphin	IND	1,819,882	0.0000%	0.0000%	0.0000%
Longman's beaked whale	IND	16,867	0.0459%	0.0000%	0.0459%
Melon-headed whale	IND	64,600	0.0145%	0.0000%	0.0145%
Pantropical spotted dolphin	IND	736,575	0.0006%	0.0000%	0.0006%
Pygmy killer whale	IND	22,029	0.0061%	0.0000%	0.0061%
Pygmy sperm whale	IND	10,541	0.0001%	0.0000%	0.0001%
Risso's dolphin	IND	452,125	0.0288%	0.0000%	0.0288%
Rough-toothed dolphin	IND	156,690	0.0007%	0.0000%	0.0007%
Short-finned pilot whale	IND	268,751	0.0156%	0.0000%	0.0156%
Sperm whale	NIND	24,446	0.0063%	0.0000%	0.0063%
Spinner dolphin	IND	634,108	0.0005%	0.0000%	0.0005%
Striped dolphin	IND	674,578	0.0104%	0.0000%	0.0104%
Mission Area 18: Panama Canal (West Approach); Winter Season					
Blue whale	ENP	1,647	0.0173%	0.0120%	0.0293%
Bryde's whale	ETP	13,000	0.0077%	0.0063%	0.0140%
Common minke whale	ETP	478	0.2171%	0.1706%	0.3877%
Fin whale	ENP	832	₽[13]	₽[13]	₽[13]
Humpback whale	Southeast Pacific stock /Central America DPS	6,000	0.0005%	0.0004%	0.0010%
Blainville's beaked whale	ETP	25,300	0.0258%	0.0000%	0.0258%
Common bottlenose dolphin	ETP	335,834	0.0344%	0.0000%	0.0344%
Cuvier's beaked whale	ETP	20,000	0.0084%	0.0000%	0.0084%
Deraniyagala's beaked whale	ETP	25,300	0.0258%	0.0000%	0.0258%
False killer whale	ETP	39,800	0.0030%	0.0000%	0.0030%
Fraser's dolphin	ETP	289,300	0.0010%	0.0000%	0.0010%
Ginkgo-toothed beaked whale	ETP	25,300	0.0190%	0.0000%	0.0190%
Killer whale	ETP	8,500	0.0051%	0.0000%	0.0051%
Kogia spp.	ETP	11,200	0.3703%	0.0000%	0.3703%
Longman's beaked whale	ETP	25,300	0.0258%	0.0000%	0.0258%
Melon-headed whale	ETP	45,400	0.0202%	0.0000%	0.0202%
Mesoplodon spp.	ETP	25,300	0.0217%	0.0000%	0.0217%
Pantropical spotted dolphin	Northeastern	640,000	0.0170%	0.0000%	0.0170%

Table 6-2. Percentage of Marine Mammal Stocks Potentially Affected by 24 Hr of SURTASS LFA Sonar Transmissions Estimated for One Season in 26 Representative Mission Areas; Percent Stock Affected (With Mitigation Applied) at MMPA Level A Is 0.0000 Percent for all Marine Mammal Stocks in all Representative Mission Areas.

Marine Mammal Species	*Stock[12] Name*	*Stock Abundance*	*Percent Stock Affected—Behavioral Risk*	*Percent Stock Affected—TTS*	*Percent Stock Affected—Total Level B Harassment*
	Pacific Offshore				
Pygmy killer whale	ETP	38,900	0.0106%	0.0000%	0.0106%
Pygmy beaked whale	ETP	25,300	0.0268%	0.0000%	0.0268%
Risso's dolphin	ETP	110,457	0.0470%	0.0000%	0.0470%
Rough-toothed dolphin	ETP	107,633	0.0141%	0.0000%	0.0141%
Short-beaked common dolphin	ETP	3,127,203	0.0005%	0.0000%	0.0005%
Short-finned pilot whale	ETP	160,200	0.0322%	0.0000%	0.0322%
Sperm whale	ETP	22,700	0.0549%	0.0000%	0.0549%
Spinner dolphin	Eastern	1,062,879	0.0101%	0.0000%	0.0101%
Striped dolphin	ETP	964,362	0.0205%	0.0000%	0.0205%
Mission Area 19: Northeast Australian Coast; Spring Season					
Blue whale	WSP	9,250	0.0003%	0.0005%	0.0009%
Bryde's whale	WSP	20,501	0.0084%	0.0147%	0.0231%
Common minke whale	WSP	25,049	0.0528%	0.0810%	0.1337%
Fin whale	WSP	9,250	0.0063%	0.0119%	0.0182%
Humpback whale	IWC Breeding Stock E1/East Australia DPS	14,500	0.0178%	0.0308%	0.0486%
Omura's whale	WSP	1,800	0.0096%	0.0167%	0.0263%
Sei whale	WSP	7,000	0.0247%	0.0429%	0.0677%
Blainville's beaked whale	WSP	8,032	0.0150%	0.0000%	0.0150%
Common bottlenose dolphin	WSP	168,791	0.0267%	0.0000%	0.0267%
Cuvier's beaked whale	WSP	90,725	0.0144%	0.0000%	0.0144%
False killer whale	WSP	16,668	0.0520%	0.0000%	0.0520%
Fraser's dolphin	WSP	220,789	0.0097%	0.0000%	0.0097%
Gingko-toothed beaked whale	WSP	22,799	0.0053%	0.0000%	0.0053%
Killer whale	WSP	12,256	0.0021%	0.0000%	0.0021%
Kogia spp.	WSP	350,553	0.0026%	0.0000%	0.0026%
Longman's beaked whale	WSP	4,571	0.0132%	0.0000%	0.0132%
Melon-headed whale	WSP	36,770	0.0348%	0.0000%	0.0348%
Pantropical spotted dolphin	WSP	438,064	0.0086%	0.0000%	0.0086%
Pilot whales	WSP	53,608	0.0853%	0.0000%	0.0853%
Pygmy killer whale	WSP	30,214	0.0208%	0.0000%	0.0208%
Risso's dolphin	WSP	83,289	0.0382%	0.0000%	0.0382%
Rough-toothed dolphin	WSP	145,729	0.0122%	0.0000%	0.0122%
Short-beaked common dolphin	WSP	3,286,163	0.0053%	0.0000%	0.0053%
Sperm whale	WSP	102,112	0.0027%	0.0000%	0.0027%
Spinner dolphin	WSP	1,015,059	0.0002%	0.0000%	0.0002%
Striped dolphin	WSP	570,038	0.0158%	0.0000%	0.0158%

Table 6-2. Percentage of Marine Mammal Stocks Potentially Affected by 24 Hr of SURTASS LFA Sonar Transmissions Estimated for One Season in 26 Representative Mission Areas; Percent Stock Affected (With Mitigation Applied) at MMPA Level A Is 0.0000 Percent for all Marine Mammal Stocks in all Representative Mission Areas.

Marine Mammal Species	*Stock[12] Name*	*Stock Abundance*	*Percent Stock Affected—Behavioral Risk*	*Percent Stock Affected—TTS*	*Percent Stock Affected—Total Level B Harassment*
Mission Area 20: Northwest Australia; Winter Season					
Antarctic minke whale	ANT	90,000	₽[13]	₽[13]	₽[13]
Blue whale	SIND	1,657	₽[13]	₽[13]	₽[13]
Bryde's whale	SIND	13,854	0.0112%	0.0035%	0.0147%
Common minke whale	IND	257,500	₽[13]	₽[13]	₽[13]
Fin whale	SIND	38,185	0.0001%	0.0000%	0.0001%
Humpback whale	WAU stock and DPS	13,640	₽[13]	₽[13]	₽[13]
Omura's whale	IND	13,854	0.0112%	0.0035%	0.0147%
Sei whale	IND	13,854	0.0004%	0.0001%	0.0005%
Blainville's beaked whale	IND	16,867	0.0130%	0.0000%	0.0130%
Common bottlenose dolphin	IND	3,000	2.2106%	0.0000%	2.2106%
Cuvier's beaked whale	IND	76,500	0.0138%	0.0000%	0.0138%
Dwarf sperm whale	IND	10,541	0.0012%	0.0000%	0.0012%
False killer whale	IND	144,188	0.0004%	0.0000%	0.0004%
Fraser's dolphin	IND	151,554	0.0026%	0.0000%	0.0026%
Killer whale	IND	12,593	0.1348%	0.0000%	0.1348%
Longman's beaked whale	IND	16,867	0.0614%	0.0000%	0.0614%
Melon-headed whale	IND	64,600	0.0288%	0.0000%	0.0288%
Pantropical spotted dolphin	IND	736,575	0.0022%	0.0000%	0.0022%
Pygmy killer whale	IND	22,029	0.0118%	0.0000%	0.0118%
Risso's dolphin	IND	452,125	0.0459%	0.0000%	0.0459%
Rough-toothed dolphin	IND	156,690	0.0012%	0.0000%	0.0012%
Short-finned pilot whale	IND	268,751	0.0245%	0.0000%	0.0245%
Southern bottlenose whale	IND	599,300	0.0005%	0.0000%	0.0005%
Spade-toothed beaked whale	IND	16,867	0.0130%	0.0000%	0.0130%
Sperm whale	SIND	24,446	0.0094%	0.0000%	0.0094%
Spinner dolphin	IND	634,108	0.0020%	0.0000%	0.0020%
Striped dolphin	IND	674,578	0.0398%	0.0000%	0.0398%
Mission Area 21: Northeast of Japan; Summer Season					
Blue whale	WNP	9,250	0.0032%	0.0207%	0.0240%
Common minke whale	WNP "O"	25,049	0.2524%	2.0587%	2.3111%
Fin whale	WNP	9,250	0.0663%	0.3923%	0.4586%
Humpback whale	WNP stock and DPS	1,328	0.0990%	3.3158%	3.4148%
North Pacific right whale	WNP	922	0.0248%	0.3640%	0.3888%
Sei whale	NP	7,000	0.0877%	0.5184%	0.6061%
Western North Pacific gray whale	WNP stock/Western DPS	140	0.0086%	0.0040%	0.0126%
Baird's beaked whale	WNP	8,000	1.6190%	0.0000%	1.6190%

Table 6-2. Percentage of Marine Mammal Stocks Potentially Affected by 24 Hr of SURTASS LFA Sonar Transmissions Estimated for One Season in 26 Representative Mission Areas; Percent Stock Affected (With Mitigation Applied) at MMPA Level A Is 0.0000 Percent for all Marine Mammal Stocks in all Representative Mission Areas.

Marine Mammal Species	*Stock[12] Name*	*Stock Abundance*	*Percent Stock Affected—Behavioral Risk*	*Percent Stock Affected—TTS*	*Percent Stock Affected—Total Level B Harassment*
Cuvier's beaked whale	WNP	90,725	0.1015%	0.0000%	0.1015%
Dall's porpoise	WNP	173,638	0.9080%	0.0000%	0.9080%
Killer whale	WNP	12,256	1.4834%	0.0000%	1.4834%
Pacific white-sided dolphin	NP	931,000	0.0180%	0.0000%	0.0180%
Short-beaked common dolphin	WNP	3,286,163	0.1428%	0.0000%	0.1428%
Sperm whale	NP	102,112	0.0289%	0.0000%	0.0289%
Stejneger's beaked whale	WNP	8,000	0.1066%	0.0000%	0.1066%
Northern fur seal	Western Pacific	503,609	0.0712%	0.0000%	0.0712%
Ribbon seal	NP	61,100	1.5390%	0.0118%	1.5509%
Spotted seal	Alaska stock/Bering Sea DPS	460,268	₽[13]	₽[13]	₽[13]
Steller sea lion	Western-Asian stock and Western DPS	68,218	0.0004%	0.0000%	0.0004%
Mission Area 22: Gulf of Alaska; Summer Season					
Blue whale	ENP	1,647	0.0000%	0.0000%	0.0000%
Common minke whale	AK	1,233	1.5012%	6.8905%	8.3917%
Eastern North Pacific gray whale	ENP	20,990	0.0259%	0.1815%	0.2074%
Fin whale	AK/Northeast Pacific	1,368	1.1227%	6.4168%	7.5395%
Humpback whale	WNP and CNP stocks/Hawaii, Mexico, and WNP DPSs	10,103	0.0025%	0.0020%	0.0044%
North Pacific right whale	ENP	31	1.9699%	1.0916%	3.0615%
Sei whale	ENP	126	1.4725%	1.6000%	3.0725%
Baird's beaked whale	AK	847	0.7937%	0.0000%	0.7937%
Cuvier's beaked whale	AK	6,590	0.6249%	0.0000%	0.6249%
Dall's porpoise	AK	173,638	0.7273%	0.0000%	0.7273%
Killer whale	ENP AK Resident	2,347	0.0141%	0.0000%	0.0141%
	ENP Gulf of Alaska, Aleutian Islands, and Bering Sea Transient	587	1.4685%	0.0000%	1.4685%
Pacific white-sided dolphin	NP	26,880	1.9308%	0.0000%	1.9308%
Sperm whale	NP	102,112	0.0148%	0.0000%	0.0148%

Table 6-2. Percentage of Marine Mammal Stocks Potentially Affected by 24 Hr of SURTASS LFA Sonar Transmissions Estimated for One Season in 26 Representative Mission Areas; Percent Stock Affected (With Mitigation Applied) at MMPA Level A Is 0.0000 Percent for all Marine Mammal Stocks in all Representative Mission Areas.

Marine Mammal Species	*Stock[12] Name*	*Stock Abundance*	*Percent Stock Affected—Behavioral Risk*	*Percent Stock Affected—TTS*	*Percent Stock Affected—Total Level B Harassment*
Stejneger's beaked whale	AK	694	2.0343%	0.0000%	2.0343%
Northern elephant seal	California Breeding	179,000	0.0513%	0.0003%	0.0515%
Northern fur seal	EP	648,534	0.0824%	0.0000%	0.0824%
Ribbon seal	AK	184,000	0.0000%	0.0000%	0.0000%
Stellar Sea Lion	Eastern U.S. stock/Eastern DPS	60,131	0.0017%	0.0000%	0.0017%
	Western U.S. stock/Western DPS	49,497	0.3218%	0.0000%	0.3218%
Mission Area 23: Norwegian Basin; Summer Season					
Blue whale	ENA	979	0.0108%	0.0047%	0.0154%
Common minke whale	Northeast Atlantic	78,572	0.3117%	0.0514%	0.3631%
Fin whale	North-West Norway	6,409	0.2578%	0.2126%	0.4705%
Humpback whale	Iceland stock/ Cape Verdes-West Africa and West Indies DPSs	11,572	0.0066%	0.0011%	0.0077%
Sei whale	Iceland-Denmark Strait	10,300	0.0007%	0.0001%	0.0008%
Atlantic white-sided dolphin	ENA	3,904	0.0006%	0.0000%	0.0006%
Cuvier's beaked whale	ENA	6,992	0.8572%	0.0000%	0.8572%
Harbor porpoise	ENA	375,358	0.0059%	0.0000%	0.0059%
Killer whale	Northern Norway	731	0.0073%	0.0000%	0.0073%
Long-finned pilot whale	ENA	128,093	0.1955%	0.0000%	0.1955%
Northern bottlenose whale	ENA	19,538	0.0928%	0.0000%	0.0928%
Sowerby's beaked whale	ENA	6,992	0.8572%	0.0000%	0.8572%
Sperm whale	ENA	7,785	0.2627%	0.0000%	0.2627%
White-beaked dolphin	ENA	16,536	0.1567%	0.0000%	0.1567%
Hooded seal	West Ice	84,020	0.0660%	0.0008%	0.0660%
Mission Area 24: Western North Atlantic (off Norfolk, VA); Summer Season					
Common minke whale	Canadian East Coast	20,741	0.0023%	0.0005%	0.0029%
Fin whale	WNA	1,618	0.1852%	0.0640%	0.2491%
Humpback whale	Gulf of Maine stock/West	12,312	0.0015%	0.0001%	0.0016%

Table 6-2. Percentage of Marine Mammal Stocks Potentially Affected by 24 Hr of SURTASS LFA Sonar Transmissions Estimated for One Season in 26 Representative Mission Areas; Percent Stock Affected (With Mitigation Applied) at MMPA Level A Is 0.0000 Percent for all Marine Mammal Stocks in all Representative Mission Areas.

Marine Mammal Species	*Stock[12] Name*	*Stock Abundance*	*Percent Stock Affected—Behavioral Risk*	*Percent Stock Affected—TTS*	*Percent Stock Affected—Total Level B Harassment*
	Indies DPS				
North Atlantic right whale	WNA	476	0.0000%	0.0000%	0.0000%
Atlantic spotted dolphin	WNA	44,715	0.3088%	0.0000%	0.3088%
Clymene dolphin	WNA	6,086	0.3355%	0.0000%	0.3355%
Common bottlenose dolphin	Offshore WNA	77,532	0.0973%	0.0000%	0.0973%
	Northern Migratory Coastal	11,548	0.0000%	0.0000%	0.0000%
	Southern Migratory Coastal	9,173	0.0000%	0.0000%	0.0000%
Cuvier’s beaked whale	WNA	6,532	0.3596%	0.0000%	0.3596%
False killer whale	WNA	442	0.0357%	0.0000%	0.0357%
Killer whale	WNA	67	0.0337%	0.0000%	0.0337%
Kogia spp.	WNA	3,785	0.0494%	0.0000%	0.0494%
Mesoplodon spp.	WNA	7,092	0.3599%	0.0000%	0.3599%
Pantropical spotted dolphin	WNA	3,333	0.2215%	0.0000%	0.2215%
Risso’s dolphin	WNA	18,250	0.2879%	0.0000%	0.2879%
Rough-toothed dolphin	WNA	271	0.5222%	0.0000%	0.5222%
Short-beaked common dolphin	WNA	173,486	0.0877%	0.0000%	0.0877%
Short-finned pilot whale	WNA	21,515	0.2680%	0.0000%	0.2680%
Sperm whale	WNA	2,288	1.5558%	0.0000%	1.5558%
Spinner dolphin	WNA	262	0.1861%	0.0000%	0.1861%
Striped dolphin	WNA	54,807	0.3491%	0.0000%	0.3491%
Mission Area 25: Labrador Sea; Winter Season					
Blue whale	WNA	440	0.0973%	0.6610%	0.7583%
Common minke whale	Canadian East Coast	20,741	0.0158%	0.1374%	0.1532%
Fin whale	Canadian East Coast	1,352	0.0998%	0.5490%	0.6488%
Humpback whale	Newfoundland-Labrador stock/West Indies DPS	12,312	0.0383%	0.4193%	0.4576%
North Atlantic right whale	WNA	476	0.0000%	0.0000%	0.0000%
Sei whale	Labrador Sea	965	0.0467%	0.3367%	0.3834%
Atlantic white-sided dolphin	Labrador Sea	24,422	0.2859%	0.0000%	0.2859%
Harbor porpoise	Newfoundland	3,326	0.0715%	0.0000%	0.0715%
Killer whale	WNA	67	0.5844%	0.0000%	0.5844%
Long-finned pilot whale	Canadian East	6,134	0.0000%	0.0000%	0.0000%

Table 6-2. Percentage of Marine Mammal Stocks Potentially Affected by 24 Hr of SURTASS LFA Sonar Transmissions Estimated for One Season in 26 Representative Mission Areas; Percent Stock Affected (With Mitigation Applied) at MMPA Level A Is 0.0000 Percent for all Marine Mammal Stocks in all Representative Mission Areas.

Marine Mammal Species	*Stock[12] Name*	*Stock Abundance*	*Percent Stock Affected—Behavioral Risk*	*Percent Stock Affected—TTS*	*Percent Stock Affected—Total Level B Harassment*
	Coast				
Northern bottlenose whale	Davis Strait	50	0.6543%	0.0000%	0.6543%
Short-beaked common dolphin	WNA	173,486	0.0227%	0.0000%	0.0227%
Sowerby's beaked whale	WNA	50	0.3187%	0.0000%	0.3187%
Sperm whale	WNA	2,288	0.8136%	0.0000%	0.8136%
White-beaked dolphin	Canadian East Coast	15,625	0.1721%	0.0000%	0.1721%
Harp seal	WNA	7,411,000	0.0405%	0.0024%	0.0428%
Hooded seal	WNA	592,100	0.0458%	0.0004%	0.0461%
Ringed seal	Arctic	787,000	0.3948%	0.0230%	0.4178%
Mission Area 26: Sea of Okhotsk; Spring Season					
Bowhead whale	Okhotsk Sea	247	0.0005%	0.0186%	0.0191%
Common minke whale	WNP "O"	25,049	0.0068%	0.4192%	0.4260%
	WNP "J"	893	0.0069%	0.4221%	0.4290%
Fin whale	WNP	9,250	0.0004%	0.0139%	0.0143%
Humpback whale	WNP stock and DPS	1,328	0.0058%	0.3833%	0.3892%
North Pacific right whale	WNP	922	₽[13]	₽[13]	₽[13]
Western North Pacific gray whale	WNP stock/Western DPS	140	₽[13]	₽[13]	₽[13]
Baird's beaked whale	WNP	8,000	0.0604%	0.0000%	0.0604%
Beluga	Okhotsk Sea	12,226	0.1523%	0.0000%	0.1523%
Dall's porpoise	WNP *dalli*-type	111,402	0.3907%	0.0000%	0.3907%
	WNP *truei*-type	101,173	0.3907%	0.0000%	0.3907%
Harbor porpoise	WNP	31,046	0.1916%	0.0000%	0.1916%
Killer whale	Okhotsk-Kamchatka-Western Aleutians Transient	12,256	0.0968%	0.0000%	0.0968%
Pacific white-sided dolphin	NP	931,000	0.0016%	0.0000%	0.0016%
Sperm whale	NP	102,112	0.0023%	0.0000%	0.0023%
Bearded seal	Okhotsk stock and DPS	200,000	0.0215%	0.0005%	0.0220%
Northern fur seal	Western Pacific	503,609	0.0385%	0.0000%	0.0385%
Ribbon seal	Sea of Okhotsk	124,000	0.2941%	0.0029%	0.2970%
Ringed seal	Okhotsk	676,000	0.1425%	0.0014%	0.1439%
Spotted seal	Sea of Okhotsk stock and DPS	180,000	0.6207%	0.0062%	0.6269%

Table 6-2. Percentage of Marine Mammal Stocks Potentially Affected by 24 Hr of SURTASS LFA Sonar Transmissions Estimated for One Season in 26 Representative Mission Areas; Percent Stock Affected (With Mitigation Applied) at MMPA Level A Is 0.0000 Percent for all Marine Mammal Stocks in all Representative Mission Areas.

Marine Mammal Species	***Stock[12] Name***	***Stock Abundance***	***Percent Stock Affected—Behavioral Risk***	***Percent Stock Affected—TTS***	***Percent Stock Affected—Total Level B Harassment***
Steller sea lion	Western stock and DPS	82,516	0.0815%	0.0000%	0.0815%

7 IMPACTS TO MARINE MAMMAL SPECIES OR STOCKS

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

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 NOAA (2016a) guidance specifies auditory weighted (SELcum) values for the onset of PTS, which is considered as the onset of injury. The NOAA guidance (2016a) also categorized marine mammals into five functional hearing groups:

- 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

NOAA's (2016a) guidance presents the auditory weighting functions developed for each of these functional hearing groups that reflect the best available data on hearing, impacts of noise on hearing, and data on equal latency. When estimating the onset of injury (PTS), the NOAA guidance (2016a) defines weighted thresholds as SELs (Table 8). To determine the SEL for each hearing group exposed to a 60-sec (length of a nominal LFA transmission or 1 ping), 300 Hz (the center frequency in the possible transmission range of 100 to 500 Hz) SURTASS LFA sonar transmission, the length of the LFA signal must be considered. The length of a nominal LFA transmission is 60 sec, which lowers the thresholds by approximately 18 dB SEL ($10x\log_{10}$ [60 sec] =17.8) if the assumption is made that all RLs are at the same SPL. In addition, the auditory weighting functions must be applied to account for each functional 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 $20 \times \log_{10}$ [range {m}]), all functional 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 an entire LFA sonar ping (60 sec).

The NOAA (2016a) acoustic guidance was used in analysis and modeling of real-world potential mission areas for SURTASS LFA sonar to assess the potential for Level A harassment or auditory injury to marine mammals resulting from use of the sonar. Although it is impossible for the Navy to accurately predict where SURTASS LFA sonar will be operated in the future, twenty-six real-world marine environments suitable as potential mission areas for SURTASS LFA sonar were selected for analysis and modeling to predict pre-operational Level A harassment or injury values. The comprehensive modeling and analysis has resulted in no (0 percent) estimated risk of Level A harassment for any marine mammal species or stocks, given that the full suite of mitigation measures were employed (Table 9).

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 signal (Finneran, 2003).

To date, no strandings of marine mammals have been associated with the employment of SURTASS LFA sonar since its use began the early 2000s. Operation 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 2015. 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 and is not reasonably expected from future deployment and use of LFA sonar. Thus, for this application, the only impacts anticipated from SURTASS LFA sonar transmission are short-term Level B behavioral harassment that will affect only a small percentage of the marine mammal stocks (no more than 12 percent of any one stock on an annual basis).

Based on the results of the analyses conducted for SURTASS LFA sonar and more than thirteen years of documented operational results that are summarized in this application and presented in the NEPA documentation, operation of SURTASS LFA sonar, when employed 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 reasonably expected to be limited to Level B harassment. The Navy does not estimate the Level B impacts to impact rates of recruitment or survival on the associated marine mammal species and stocks. Thus, impacts on recruitment or survival are expected to be negligible.
    - Level B harassment of marine mammals will 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. Twenty-two areas of global importance to marine mammals have been designated (Table 2-23) with eleven areas added or expanded as part of this Proposed Action (Table 2-3), so received levels above 180 dB rms will not occur in these essential marine habitats.
- Potential for non-injurious impacts (TTS, masking, modification of biological important behavior, physiological stress) is minimal to negligible for marine mammals.
- Based on the Navy‘s impact analysis results, no mortality nor injury (i.e., Level A harassment) of marine mammals is predicted to occur as a result of SURTASS LFA sonar, and the potential to cause strandings of marine mammals is considered negligible.

- The employment of SURTASS LFA sonar will 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 operation. With the nominal duty cycle of 7.5 to 10 percent, masking by LFA sonar would only occur over a very small temporal scale. Also, no more than four SURTASS LFA sonar systems would operate in the world's oceans over the next five years. The cumulative impacts related to the potential for masking from the four SURTASS LFA sonar systems are not a reasonably foreseeable significant adverse impact on marine animals.
- Employment of SURTASS LFA sonar will not impact the habitat of marine mammals nor result in loss or modification of marine habitat.
- The availability of marine mammals for subsistence use will not be adversely impacted.
- Annually, each of the four SURTASS LFA sonar vessels will spend no more than 240 days performing active operations with a maximum of 255 hr of sonar transmission per vessel per year.
- A comprehensive suite of mitigation measures, including three types of monitoring (passive acoustic, active acoustic, and visual) during sonar operations, 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), will be implemented to reduce the potential for harassment to marine mammals.

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 employment of SURTASS LFA sonar in any of the potential worldwide mission areas will 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.

Although SURTASS LFA sonar will not be operated in the vast majority of Arctic waters, the sonar may potentially be operated in the Gulf of Alaska or off the Aleutian Island chain where Alaska Native subsistence uses of marine mammals occurs. Seven species of pinnipeds, one species of odontocetes (beluga whale), and one species of mysticetes (bowhead whale) are targeted by subsistence hunting. The stocks of beluga whales that experience Alaska Native subsistence hunting are located in Arctic waters and would not be impacted by SURTASS LFA sonar. The Western Arctic stock of bowhead whales experiences subsistence hunting from Alaska, Canadian, and Russian Natives, but would not occur in operational areas of SURTASS LFA sonar and would not be impacted by sonar transmissions. The distributions of bearded and ringed seals overlap operational areas of SURTASS LFA sonar in the Sea of Okhotsk, but these are not stocks that experience Alaska Native subsistence hunting. The Alaska Native harvest of harbor seals from twelve stocks identified in Alaska occurs at haul-out sites within the coastal standoff geographic restriction of SURTASS LFA sonar.

The remaining four species of pinnipeds, northern fur seal, ribbon seal, spotted seal, and Steller sea lion, experience Native Alaska subsistence hunting and may be exposed to SURTASS LFA sonar transmissions. Northern fur seals are primarily hunted in the Pribilof Islands of the Bering Sea, where, from 2009 to 2013, an annual average of 432 northern fur seals, primarily subadult males, was harvested (Muto et al., 2016). Individuals from this stock may occur south of the Aleutian Island archipelago within the SURTASS LFA sonar operational area. Pinnipeds are not low-frequency hearing specialists and the potential for impacts from SURTASS LFA sonar are limited to a minimal risk for behavioral change (Table 9). Therefore, there would be no impact on Alaska Native subsistence hunting of northern fur seals.

Ribbon seals are an important resource to sixty-four communities in western and northern Alaska, from Bristol Bay in the Bering Sea to Kaktovik in the Beaufort Sea (Muto et al., 2016). Of the sixty-four communities, eleven were surveyed, from which a minimum annual estimate of 3.2 seals were harvested between 2009 and 2013. Ribbon seals are ice-associated phocids that may occur south of the Aleutian Islands during certain times of the year. Pinnipeds are not low-frequency hearing specialists and the potential for impacts to ribbon seals from SURTASS LFA sonar are limited to a minimal risk for behavioral change (Table 9). Therefore, there would be no impact on Alaska Native subsistence hunting of ribbon seals.

Spotted seals are important to subsistence hunting in the Bering Strait and Yukon-Kuskokwim regions (Muto et al., 2016). The last reliable population estimate for the Alaska stock/Bering Sea DPS was 460,268 seals (Allen and Angliss, 2015). Spotted seals spend their time either in open-ocean waters or in pack-ice habitats throughout the year, with their range expanding and contracting in association with ice cover (Burns, 2009). Few data are available for an accurate estimate of animals harvested and struck but lost, but the best estimate is 5,265 animals per year (Muto et al., 2016). Spotted seals can hear underwater, with their best sensitivity between 2 and 30 kHz (Sills et al., 2014). The potential for impacts to spotted seals from SURTASS LFA sonar are limited to a minimal risk for behavioral change (Table 9). Therefore, there would be no impact on Alaska Native subsistence hunting of spotted seals.

Steller sea lions are divided taxonomically into two species that effectively represent the Western and Eastern stocks and DPSs (SMM, 2016). The Western stock/DPS is listed as endangered under the ESA, whereas the Eastern stock/DPS was delisted under the ESA in 2013. Steller sea lions are found in temperate or sub-polar waters and are widely distributed throughout the North Pacific from Japan to central California, and in the southern Bering Sea. Subsistence hunting within the range of the Western stock/DPS primarily occurs at St. Paul Island in the Bering Sea and Kodiak Island in the Gulf of Alaska. Near real-time data on the harvest was collected on St. Paul Island from 2008 to 2011 and in 2013. Interviews of 2,100 households within sixty coastal communities were conducted during the 2004 to 2008 hunting seasons. Based on these data, an estimate of approximately 200 seals within the Western stock/DPS and 11 seals within the Eastern stock/SPS are harvested and struck but lost each year (Muto et al., 2016). In a study of underwater hearing sensitivity, male Steller sea lion had maximum sensitivity at 1 kHz, with the range of best hearing extending to 10 kHz, whereas the female Steller sea lion had maximum sensitivity at 25 kHz (Kastelein et al. 2005). Pinnipeds are not low-frequency hearing specialists and the potential for impacts from SURTASS LFA sonar are limited to a minimal risk for behavioral change (Table 9). Therefore, there would be no impact on Alaska Native subsistence hunting of Steller sea lions in either the Western stock/DPS or Eastern stock/DPS.

During the review and comment period for the Draft SEIS/SOEIS for SURTASS LFA sonar employment (DoN, 2016a), letters requesting review of the Draft SEIS/SOEIS will be distributed and comments will have been solicited from Alaska Native groups. Should SURTASS LFA sonar be operated in the Gulf of Alaska, sonar operation would adhere to established geographic restrictions, which include the coastal standoff range and OBIAs, which dictate that the sound field produced by the sonar must be below 180 dB SPL within 22 km (12 nmi) of any coastline and within OBIAs. An existing OBIA in the Gulf of Alaska has been proposed to be expanded to include recent sightings of North Pacific right whales outside of defined critical habitat. The existing OBIA as well as the expanded region occur just off Kodiak Island (Figure 8-1).

Although there are peaks in harvest activity, most subsistence hunting occurs in winter months of January to March when seals have restricted distributions on the ice front. While it is impossible to predict the future timing of the possible employment of SURTASS LFA sonar in the Gulf of Alaska, regardless of the time of year the sonar may be employed in the Gulf of Alaska, there should be no overlap in time or space with subsistence hunts due to the geographic restrictions on the sonar use (i.e., coastal standoff range and OBIA restrictions). These restrictions will prevent the sonar from being used or the sound field it generates from reaching the shallow coastal and inshore areas of the Gulf of Alaska where harvest of pinniped species primarily occurs. The possible employment of SURTASS LFA sonar in the Gulf of Alaska will not cause abandonment of any harvest/hunting locations, will not displace any subsistence users, nor place physical barriers between marine mammals and the hunters. No mortalities of marine mammals have been associated with the employment of SURTASS LFA sonar and the Navy undertakes a suite of mitigation measures whenever SURTASS LFA sonar is actively transmitting. Therefore, the possible future employment of SURTASS LFA sonar will not lead to unmitigatable adverse impacts on the availability of marine mammal species or stocks for the subsistence uses in the Gulf of Alaska or along the Aleutian Island Chain.

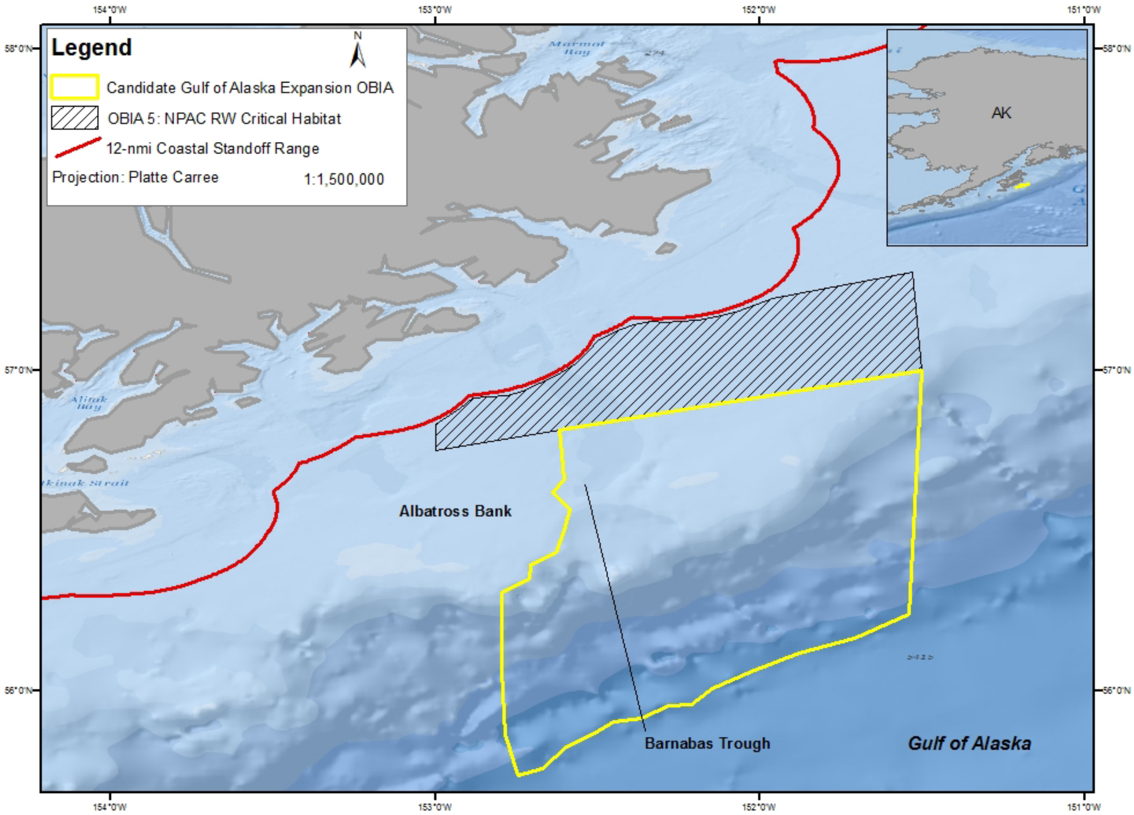

Figure 8-1. Gulf of Alaska Potential OBIA.

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 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 will result from the operation of the sonar systems nor will unregulated environmental impacts from the operation of the SURTASS LFA sonar vessels occur.

9.2 Sound in the Environment

Deployment and 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 that up to four SURTASS LFA sonars may have 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 operations 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 will 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 will 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, will 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 will 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 will temporarily add to the ambient noise level in the frequency band (100 to 500 Hz) in which LFA operates, but the impact on the overall noise levels in the ocean will be minimal. In most of the ocean, the 10 to 500 Hz portion of the ambient noise spectrum is dominated by anthropogenic noise sources, particularly shipping and seismic airguns. Commercial vessels are the most common source of low-frequency noise and their impact on ambient noise is basin-wide (Hildebrand, 2009).

SURTASS LFA sonar produces a coherent low-frequency signal with a duty cycle of less than 20 percent and an average pulse length of 60 sec. The operational time for this system under Alternative 1 is a maximum of 432 hours per year for up to four vessels. This compares to approximately 22 million ship-days per year for the world's commercial shipping industry, presuming an 80 percent activity rate. 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; mid-frequency military sonar was estimated to contribute 2.6×10^{13} Joules/yr; and each LFA sonar vessel operating at 432 hr/yr was estimated to contribute 1.7×10^{11} Joules/yr (Hildebrand, 2005). The percentage of the total anthropogenic acoustic energy budget added by each LFA source is estimated to be 0.25 percent when these anthropogenic sources are considered (Hildebrand, 2005). Therefore, within the existing ocean environment, the potential for accumulation of noise due to the intermittent operation of SURTASS LFA sonar is considered negligible (DoN, 2012).

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.

One hundred thirty-nine marine and anadromous species have been listed as threatened or endangered under the ESA, including 49 foreign species (NMFS, 2016). Of those, critical habitat has only been designated for six ESA-listed marine mammals (Table 9-1; NMFS, 2016). Although NMFS has jurisdiction over many marine and anadromous species listed under ESA and their designated critical habitat, the USFWS also has jurisdiction over marine/anadromous species, such as the manatee, polar bear, walrus, and sea otter; and shares jurisdiction with NMFS for some species, such as the Atlantic salmon, gulf sturgeon, and all sea turtles. Of the designated critical habitat for marine mammals, the critical habitat of only four of the designated marine mammal species is in the marine environment at a distance sufficient from shore to potentially be affected by SURTASS LFA sonar.

For this reason, the more extensive OBIA analysis considered these critical habitat areas and designated all but the critical habitat of the Steller sea lion as a marine mammal OBIA for SURTASS LFA sonar. Much of the critical habitat for the Steller sea lion is located in the Bering Sea, where SURTASS LFA sonar will not operate. Although it is possible that the sonar will be operated in the western Gulf of Alaska where the eastern critical habitat for the Steller sea lion is located and some of that habitat lies outside of 12

Table 9-1. ESA-listed Marine Mammal Species for Which Critical Habitat has been Designated.

ESA-listed Marine Mammal Species	Status Under ESA	Listed DPS	Critical Habitat—Type of Habitat Designated
Beluga whale	Endangered	Cook Inlet	Inland estuarine habitat
Killer whale	Endangered	Southern Resident	Inland marine and estuarine habitat
North Atlantic right whale	Endangered		Marine neritic habitat; marine neritic habitat <12 nmi (22 km) encompassed in OBIAs (#3 and 4)
North Pacific right whale	Endangered		Polar (Bering Sea) marine habitat; marine habitat in Gulf of Alaska encompassed in OBIA (#5)
Hawaiian monk seal	Endangered		Marine neritic benthic (bottom 33 ft (10 m) of habitat from shore to 656-ft [200-m] isobath) and onshore nesting beach habitat
Steller sea lion	Endangered	Western	Polar (Bering Sea) neritic habitat; Gulf of Alaska/Aleutian/CA neritic (< 20 nmi [37 km]) and onshore habitat

nmi (22 km) from shore, the water depth in which the habitat is found is sufficiently shallow that it is unlikely that the sonar would ever be operated in the vicinity of that critical habitat. Thus, the likelihood of SURTASS LFA sonar adversely affecting critical habitats is negligible.

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). In the U.S., a MPA is defined by EO 13158 as "any area of the marine environment that has been reserved by federal, state, territorial, tribal, or local laws or regulations to provide lasting protection for part or all of the natural and cultural resources therein."

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

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 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, twelve of those listed in the National System MPAs are in potential SURTASS LFA sonar operating areas, 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:

- Olympic Coast NMS
- Greater Farallones NMS
- Monterey Bay NMS
- Cordell Bank NMS
- Stellwagen Bank NMS
- Penguin Bank area of the Hawaiian Islands Humpback Whale NMS
- NMS of American Samoa
- Monitor NMS
- Gray's Reef NMS
- Flower Garden Banks NMS
- Florida Keys NMS
- Papahānaumokuākea Marine National Monument (NOAA, 2015).

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 5,000 MPAs exist globally (Agardy et al., 2003; WDPA, 2009). International waters (i.e., the high seas) are contained within the boundaries of some MPAs such as the Pelagos Sanctuary for the Conservation of Marine Mammals in the Mediterranean (WDPA, 2009). 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).

Excluding the Arctic and Antarctic regions of the world's oceans, approximately 10 internationally-designated MPAs exist in waters in which SURTASS LFA sonar may potentially operate. The largest of these MPAs, Phoenix Islands Protected Area, established by the Republic of Kiribati in the southern Pacific Ocean, encompasses 415,000 km^2 of ocean area (WDPA, 2009).

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. Several of the marine mammal MPAs are amongst the 28 potential OBIAs where SURTASS LFA sonar use will be restricted to keeping the received sound level less than 180 dB re 1 µPa (rms) during biologically important seasons. Areas such as Penguin Bank, of the Hawaiian Islands Humpback Whale National Marine Sanctuary, and an area in the northern Ligurian Sea, part of the Pelagos Whale Sanctuary, for example, have been designated as OBIAs so that these critical areas for marine mammals are restricted from SURTASS LFA sonar use.

Potential impacts on critical habitat and MPAs relate to the transmission of LF sound by SURTASS LFA sonar. There is no potential for physical or chemical alterations of the water or substrate from sound transmissions. There is a potential for SURTASS LFA sonar to temporarily add to the ambient noise levels when it is transmitting. 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 a maximum of 255 hr/vessel/yr. Therefore, there is little to no potential for impacts to MPAs. There is also limited to no potential for indirect impacts to the habitat on 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 will be affected by the operation of SURTASS LFA sonar.

10 IMPACTS TO MARINE MAMMALS FROM HABITAT LOSS OR MODIFICATION

<u>*Requirement 10*</u>: *Anticipated impact of the loss or modification of the habitat on the marine mammal populations involved.*

Use of up to four SURTASS LFA sonar systems in ocean areas beyond 12 nmi (22 km) from shore, outside of potential OBIAs, and in non-polar waters will not impact the habitat of marine mammals nor result in loss or modification of marine habitat. Although SURTASS LFA sonar will not harm the marine habitat, certain mitigation measures are undertaken to further guard the resources of specific types of protected habitats such as marine mammals in 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 use when SURTASS LFA sonar is transmitting 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, sea turtles, and human divers. 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 below 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 will minimize impacts on marine mammal stocks and species as well as on sea turtle stocks and recreational or commercial divers.

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 NOAA (2016a) guidance specifies auditory weighted (SEL_{cum}) values for the onset of PTS, which is considered as the onset of injury. The NOAA guidance (2016a) also categorized marine mammals into five functional 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

NOAA's (2016a) guidance presents the auditory weighting functions developed for each of these functional hearing groups that reflect the best available data on hearing, impacts of noise on hearing, and data on equal latency. When estimating the onset of injury (PTS), the NOAA guidance (2016a) defines weighted thresholds as sound exposure levels (SELs) (Table 8). To determine what the SEL for each hearing group would be when exposed to a 60-sec (length of a nominal LFA 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 functional 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 $20 \times \log_{10}$ [range {m}]), all functional 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 (see Chapter 6 for additional details). 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}[15] 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 Navy proposes to employ up to four SURTASS LFA sonar systems onboard up to four U.S. Navy surveillance ships for routine training, testing, and military operations in the Pacific, Atlantic, and Indian oceans and the Mediterranean Sea. The sound signals transmitted by the SURTASS LFA sonar source will

15 SEL_{cum}=cumulative sound exposure level

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.

Annually, each SURTASS LFA sonar vessel will be expected to spend approximately 54 days in transit and about 240 days performing LFA sonar operations, although the actual number and length of the individual missions within the 240 days are difficult to predict. The Navy is currently authorized to transmit the maximum number of 432 hours of LFA sonar transmission hours per vessel per year. In this application, the Navy is proposing to reduce the annual number of transmit hours per vessel to 255 hours of SURTASS LFA sonar transmissions.

11.2.2 Mitigation Zone

Prior to commencing SURTASS LFA sonar transmissions and during LFA sonar transmissions, the propagation of LFA sonar signals in the mission area and the distance from the SURTASS LFA sonar source to the 180 dB re 1 µPa isopleth will be determined. A mitigation zone around the LFA sonar array that is equal in size to the 180 dB re 1 µPa isopleth (i.e., the volume subjected to sound pressure levels of 180 dB or greater) will be established. Monitoring for marine animals will be conducted within the mitigation zone.

11.2.3 Interim Operational Restrictions

In the SURTASS LFA 2002 to 2007 Final Rule under the MMPA (NOAA, 2002), NMFS added an interim operational restriction 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 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 interim operational restriction be implemented. This restriction has proven to be practical under current operations, 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 interim operational restriction would not generate a change of any significance in the percentage of animals potentially affected. However, the Navy will 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 will be implemented to ensure that there will be 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 operations, the HF/M3 sonar power level will be ramped up over a period of no less than 5 minutes from a source level 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 will 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

SURTASS LFA sonar transmissions will 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 will occur if the marine animal is detected by any of the employed 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. Operations will 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 employment of SURTASS LFA sonar:

- SURTASS LFA sonar-generated sound field will 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 will be 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 operators will estimate LFA sound field RLs (SPL) prior to and during active sonar operations so that the distance from the LFA sonar system to the 180 dB re 1 µPa (rms) and 145 dB re 1 µPa (rms) isopleths are known.

LFA sonar transmissions would be suspended or delayed to ensure that received levels 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 will 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 will continue to employ the 12 nmi (22 km) coastal standoff distance while using SURTASS LFA sonar.

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 LFA sonar transmissions is minimized in areas where marine mammals conduct biologically significant behaviors (i.e., OBIAs) (see Section 2.2.2 for more information on OBIAs). Accordingly, the Navy will conduct SURTASS LFA sonar operations such that the LFA sound field will 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 operators will estimate LFA sound field RLs (SPL) prior to and during operations to provide the information necessary to modify operations, including the delay or suspension of transmissions, so that the sound field criteria referenced in this chapter are not exceeded. Sound field limits will 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 will help determine the sound field by predicting the SPLs, or RLs, at various distances from the SURTASS LFA sonar source. Acoustic model updates will nominally be made every 12 hours or more frequently, depending upon the variance in meteorological or oceanographic conditions.

11.2.8 Annual Take Limit on Marine Mammal Stocks

The operation of SURTASS LFA in military readiness activities may incidentally take marine mammals present within the Navy's mission areas by exposing them to sound from LFA sonar sources. The Navy annually requests authorization to take marine mammals by Level A and Level B harassment in the marine areas in which it anticipates operating LFA sonar during that annual period. The take estimates for the proposed operational or mission areas will be calculated annually using various inputs such as mission location, mission duration, and season of operation.

The Navy will limit operation of SURTASS LFA sonar to ensure that no more than 12 percent of any marine mammal stock would be taken by Level B harassment annually from transmissions of all SURTASS LFA sonar vessels. The Navy will use the 12 percent cap to guide its mission planning and selection of potential operational mission areas within each annual authorization application.

The Navy plans to avoid takes of marine mammals by Level A incidental harassment through implementing the complete suite of mitigation and monitoring measures described in this chapter. With the application of mitigation, the acoustic analyses results presented herein and in previous documentation for SURTASS LFA sonar translate into estimates of zero individuals taken by Level A for any species' stock. While the probability of detecting a sea turtle and especially a marine mammal with the Navy's active HF/M3 sonar system within the SURTASS LFA sonar mitigation zone is high, it is not 100 percent. For that reason, a small number of Level A harassment (non-lethal) takes of marine mammals and sea turtles have been requested by the Navy and authorized by NMFS (NMFS, 2012; NOAA, 2012a).

11.3 Monitoring to Prevent Injury to Marine Animals

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 will continue to conduct the following monitoring to prevent injury to marine animals when SURTASS LFA sonar is employed:

- **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 High Frequency Marine Mammal Monitoring (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 quarterly and annual reports to monitor for potential long-term environmental impacts.

11.3.1 Visual Monitoring

Visual monitoring will 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 will 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 train and qualify designated ship personnel to conduct at-sea visual monitoring. 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 will maintain a topside watch for marine mammals and sea turtles at the sea surface and observation log during operations that employ SURTASS LFA sonar transmissions. The numbers and identification of observed marine mammals or sea turtles, as well as any unusual behavior, will be entered into the log. A designated ship's officer will monitor the conduct of the visual watches and will 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 will notify the military crew (MILCREW) officer-in-charge (OIC), who will 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 will 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 will 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 will 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 will 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 operations, 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 (Chapter 2 and 4) for SURTASS LFA sonar (DoN, 2001) in addition to the technical report by Ellison and Stein (1999/2001). The information presented therein remains valid and is incorporated herein by reference. 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). Additionally, qualitative and quantitative assessments of the HF/M3 system's ability to detect marine mammals of various sizes were verified in 170 hr 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). Ellison and Stein (2001) reported that the detection probability would be near 100% for a moderately-sized (~33 ft [10 m]) marine mammal swimming towards the system.

11.4 Other Mitigation Measures Considered

In previous documentation for SURTASS LFA sonar, other mitigation measures, including the use of small boats and aircraft for pre-operational surveys were considered, but not carried forward (DoN, 2007, 2012). The Navy concluded that boat or aircraft pre-operational surveys were not feasible because they were not practicable, not effective, might increase the harassment of marine mammals, and were not safe to the human performers (DoN, 2007). Therefore, under the revisions to the MMPA by the NDAA of Fiscal Year 2004, pre-operational surveys were not considered as a viable mitigation option. Other discussions of recommended mitigation measures may be found in Chapter 10 of the 2007 FSEIS (DoN, 2007) and Chapter 7 of the 2012 SEIS/SOEIS (DoN, 2012).

11.4.1 Underwater Gliders

Unmanned underwater gliders are increasingly being utilized in marine research, including the study of marine mammals. Acoustic and other sensors can be attached to underwater gliders to collect data on the presence of marine mammals and potentially on some types of marine mammal behavior. The efficacy of using underwater gliders affixed with passive acoustic sensors to monitor marine mammals during SURTASS LFA sonar operations has been part of the Adaptive Management review process and further assessed for the Draft SEIS/SOEIS (DoN, 2016a) and this Rulemaking Application.

The Navy considered some of the issues associated with the potential use of underwater gliders as a mitigation measure for SURTASS LFA sonar. These issues included but were not limited to the cost of purchasing and maintaining underwater gliders, including associated operational personnel; transportation of underwater gliders to mission areas aboard SURTASS LFA sonar vessels; and deployment and recovery of underwater gliders from SURTASS LFA sonar vessels. The Navy evaluated these logistical and practicability issues in conjunction with the potential efficacy of using underwater gliders to collect real-time information on the locations and ranges of marine mammals relative to transmitting SURTASS LFA sonar systems. The principal issue associated with the use of underwater gliders is their capability of providing localized, real-time acoustic data on marine mammals.

The current suite of mitigation monitoring, including the use of passive acoustic monitoring, provides real-time data on the presence and location of marine animals in the vicinity of transmitting LFA sonar. In that context, the Navy concluded that until issues of practicability, logistics, and the fundamental capability to provide real-time data can be resolved, it is currently not feasible to employ underwater gliders as a mitigation measure for SURTASS LFA sonar.

11.5 Summary of Mitigation Measures for SURTASS LFA Sonar Use

There are a suite of mitigation measures that apply to the operation 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 Operation 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 operations 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 operations 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 operations
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 operations

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.*

Although SURTASS LFA sonar may be operated in the Gulf of Alaska or offshore of the Aleutian Island chain where subsistence hunting occurs, the sonar would not be operated in the vicinity of any of coastal and inshore locations where hunting occurs due to the geographic restrictions on the sonar use (coastal standoff range and OBIAs). Additionally, a suite of mitigation measures associated with the employment of SURTASS LFA sonar, including passive, active, and visual monitoring, are implemented to prevent injury or harm to marine mammals. Alaskan Native groups that subsistence hunt are being sent a letter notifying them of the availability of the Draft SEIS/SOEIS that the Navy prepared for the employment of SURTASS LFA sonar (DoN, 2016a). They will be asked to provide comments on the document regarding the potential for significant impact on any of their Tribal rights or resources from the proposed action. The employment of SURTASS LFA sonar will not lead to any adverse effects on subsistence-hunted marine mammals nor will 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 missions, the Navy also conducts numerous monitoring efforts that provide information about the marine environment and marine mammal occurrence and behavior.

13.1.1 Environmental Data Monitoring

The Navy will deploy expendable bathythermographs (XBT), nominally once every 12 hours, to collect environmental data (e.g., temperature gradients versus depth) during SURTASS LFA sonar operations and, as feasible, during the vessels' transits to and from mission areas.

On a pre-assigned schedule, the Navy MILCREW onboard each SURTASS LFA sonar vessel will forward these data to the Naval Oceanographic Office at Bay St. Louis, MS for processing and inclusion into the Navy's environmental databases, including the generalized digital environmental model (GDEM), the oceanographic and atmospheric master library (OAML), and the modular ocean data assimilation system (MODAS). GDEM products are available to the public directly, while MODAS records and OAML products are available to the public through the Navy's Commander Naval Meteorology and Oceanography Command.

Since the Navy conducts SURTASS LFA sonar operations in the world's oceans, incorporation of these monitoring data sets will provide the Navy and the general public with more robust and up-to-date global temperature and salinity profiles in data-poor and/or shallow areas. Inclusion of these new datasets will lead to increased gridded resolution within the Navy's current climatology data bases (i.e., GDEM, MODAS, and OAML).

The determination of the movement and activity of marine mammals, and information on the migration and other marine habitat uses by marine mammals, rely on accurate and reliable data from the GDEM, MODAS and OAML data bases. Thus, the monitoring datasets provided by SURTASS LFA sonar will lead to better understanding of the environmental characteristics of marine mammal habitat use, the factors that may drive marine mammal seasonal movements, and how these characteristics change over time. Further, these data are utilized in the planning of future SURTASS LFA sonar and other Navy ASW exercises, for input to marine mammal impact models.

13.1.2 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.

13.1.3 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 whales. At present, the M3 program's data are classified, as are the data reports created by M3 analysts, due to the inclusion of sensitive national security information. In the past, however, researchers have based unclassified research and the resulting scientific papers on information from classified M3 program data or other Navy passive acoustic assets.

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 to the public (DoN, 2015). Progress has been achieved on addressing security concerns and declassifying the results of a specific dataset pertinent to a current area of scientific inquiry for which a peer-reviewed scientific paper is being prepared for submission to a scientific journal.

13.1.4 Augmentation of Marine Mammal Data Collection

One of the types of mitigation monitoring required during SURTASS LFA sonar transmissions is the use of the SURTASS passive HLA to monitor for marine mammal vocalizations, which are indicative of the presence of marine mammals in the surrounding marine environment. In recognition of the monitoring value of the SURTASS LFA passive towed HLA, the Navy is exploring the feasibility of coordinating with other Navy fleet assets to use the SURTASS passive sonar to augment the collection of data on marine mammal vocalizations during Navy exercises and/or as an adjunct to Navy range monitoring programs. The goal would be to determine the extent, if any, of changes in marine mammal vocalizations that could have been caused by SURTASS LFA sonar or other Navy underwater acoustic systems during the exercise. Collection of such passive acoustic data would directly contribute to our knowledge of marine mammals' occurrences and responses, but would also most importantly augment the data available from the Low Frequency Sound Scientific Research Program (LFS SRP) on the potential responses of baleen whales to LF sound. If the collection of such calibrated and validated data can occur, this could be useful information in NMFS' environmental compliance processes for underwater LF sonar systems.

This effort would require long-term, detailed pre-planning and a comprehensive data collection and analysis plan, which will necessarily be subject to the fleet operations plan for the exercise itself. Other factors that would need to be addressed include the following:

- Scheduling of assets: availability of the SURTASS LFA sonar system and vessel to participate in the exercise, time for a T-AGOS vessel to transit to the location where the exercise would occur, and the time for pre- and post- exercise data collection and analysis of marine mammal vocalizations.
- Budgetary constraints: additional Navy budget allocations required for extra time at sea for the SURTASS LFA sonar vessel to participate in the exercise including collecting data before and after the exercise for data calibration, and transit to and from the exercise location.
- Potential for qualified, professional marine mammal observers to be onboard the SURTASS LFA sonar vessel during the data collection efforts. This poses a challenge since there is typically little available space on the T-AGOS vessels for additional riders, and any observers would need to possess appropriate security clearances.
- Security measures: protocols would need to be developed to ensure that the marine mammal vocalization data collected onboard the SURTASS LFA sonar vessel, or any other data collected during the exercise, can be scrubbed of any potentially classified information, such that the marine mammal data can be unclassified for processing and analysis by other scientists.
- Reconciling the potential behavioral responses of marine mammals associated with SURTASS LFA sonar transmissions versus other Navy underwater sound sources (e.g., mid-frequency active sonars).
- Accounting for other variables that may cause a change in marine mammals' vocalization output; this would be a task for a scientific team made up of marine biologists, LFA sonar operators, and oceanographic experts.

13.2 Reporting

The Navy routinely reports on the level of SURTASS LFA sonar transmissions over annual periods, the locations in which marine mammals may have been exposed to SURTASS LFA sonar, 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 employment of SURTASS LFA sonar.

13.2.1 Incident Monitoring

The crew of the SURTASS LFA sonar vessels systematically observes the sea surface during and after SURTASS LFA sonar operations 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 operations occurred and correlates the marine mammal strandings temporally and spatially with SURTASS LFA sonar operations.

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, or in the vicinity of any SURTASS LFA operations or anytime an injured, stranded, or dead marine mammal is found. 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 Quarterly Mission Reports

No later than 45 days following the end of each quarter, beginning on the date of the annual LOAs effectiveness, the Navy will submit unclassified and classified quarterly mission reports to NMFS for each SURTASS LFA sonar vessel. Reports will be submitted even if no SURTASS LFA sonar activities occurred during that quarter. If SURTASS LFA sonar missions occurred during a quarter, then a classified and unclassified action report for the vessel that conducted the sonar missions will be prepared and submitted that include all dates/times of LFA sonar missions; location of vessel/mission; mission area; , 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 will 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 quarterly mission reports will 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 operating locations, season of missions, system characteristics, oceanographic environmental conditions, and marine mammal demographics.

13.2.3 Annual Report

The Navy will submit an unclassified annual report to the NMFS Office of Protected Resources Director no later than 60 days after the end of the annual LOA effective period. The annual report on SURTASS LFA sonar operations will contain summaries of the unclassified quarterly mission reports, 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 operations.

13.2.4 Five-Year Comprehensive Report

A final comprehensive report, which is an unclassified assessment of any impacts of SURTASS LFA sonar on marine mammal stocks during the five-year period of the MMPA regulations, will be submitted by the Navy to NMFS and be made available for public review at least 240 days prior to expiration of the MMPA Final Rule regulations.

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 letters of authorization and rule-making. The adaptive management process allows NMFS, in consultation with the Navy, to modify or augment existing mitigation or monitoring measures if doing so will 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

> *<u>Requirement 14</u>: 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 2014 in which the Navy reported that it spent $29.6 million (M) that year on marine mammal research and conservation (Marine Mammal Commission [MMC], 2016). 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 Marine Species Monitoring program, with about $1M of the $29.6M being funded by the Naval Sea Systems Command and the Naval Air Systems Command (MMC, 2016). 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. In addition to funding behavioral response studies (BRSs), the LMR Program is currently funding marine mammal-related research such as the: integration of an autonomous underwater vehicle with a passive acoustic monitoring system to detect, classify, localize, and track marine mammal vocalizations; creation of a database of marine mammal vocalization detectors and classifiers that will be integrated into existing passive acoustic monitoring (PAM) software; development of automated whistle and click detectors and classifiers for odontocete species' vocalizations; and refinement of signal detector algorithms to detect specific marine mammal calls. An important goal of the LMR program is to provide the Navy's Marine Species Monitoring program with technologies and methods needed to achieve its mission.

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 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[16], 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 environmental 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.

14.2 Behavioral Response Studies

An important research effort that the Navy continues to fund is the independent research program on the behavioral responses of marine mammals to underwater sound. In this multi-year effort (2010 through 2016), the southern California BRS (SOCAL BRS) has been conducted in southern California waters to provide direct, controlled measurements of marine mammal's reactions to underwater sound, including military sonar systems. The recent and planned 2016 BRSs have been conducted on the Navy's

16 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.

Southern California (SOCAL) Range Complex with previous BRSs having been conducted in the Bahamas, on the Navy's Atlantic Undersea Test and Evaluation Center (AUTEC), and in the Mediterranean Sea (BRS 2007 through 2009). The SOCAL BRS includes collaborations among scientists and researchers from the NOAA, private sector, academia, and the Navy. The principal objective of the SOCAL BRS is to collect the data that will provide a better scientific basis for the Navy and Federal regulators to use in estimating risk and minimizing effects associated with exposure to military mid-frequency sonars. SOCAL BRS experiments have coordinated with Navy at-sea training exercises so that behavioral responses to realistic scenarios (acoustic sources and operational conditions) and full-scale sound sources can be measured, as well as using scaled underwater sound source that projects simulated military sonar signal. During the SOCAL BRS experiments, 170 tags have been deployed on nine species of marine mammals, with 83 complete BRS experiments having been conducted on the Baird's beaked whale, blue whale, Cuvier's beaked whale, fin whale, humpback whale, Risso's dolphin, and sperm whale (Southall, 2015).

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