FINAL

ENVIRONMENTAL ASSESSMENT/ OVERSEAS ENVIRONMENTAL ASSESSMENT FOR THE LONG RANGE STRIKE WEAPON SYSTEMS EVALUATION PROGRAM AT THE PACIFIC MISSILE RANGE FACILITY AT KAUAI, HAWAII

PREPARED FOR:
Department of the Air Force
Air Force Civil Engineer Center, NEPA Division
AFCEC/CZN

October 2016

Letters or other written comments provided may be published in the Final EA/OEA. As required by law, substantive comments will be addressed in the Final EA/OEA and made available to the public. Any personal information provided will be kept confidential. Private addresses will be compiled to develop a mailing list for those requesting copies of the Final EA/OEA. However, only the names of the individuals making comments and their specific comments will be disclosed. Personal home addresses and phone numbers will not be published in the Final EA/OEA.

This page is intentionally blank.

Table of Contents

List of Tables

List of Figures

Glossary of Acronyms, Symbols, and Abbreviations

° N	degrees North
° W	degrees West
°C	degrees Celsius
°F	degrees Fahrenheit
86 FWS	86th Fighter Weapons Squadron
ACAM	Air Conformity Applicability Model
AESO	Aircraft Environmental Support Office
AFB	Air Force Base
AGL	above ground level
APE	Area of Potential Effects
AWOIS	Advanced Wreck and Obstruction Information System
BO	Biological Opinion
BSURE	Barking Sands Underwater Range Extension
CBSFA	Community-Based Subsistence Fishing Area
CBU	Cluster Bomb Unit
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CH_4	methane
CO	carbon monoxide
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
CV	coefficient of variation
CZMA	Coastal Zone Management Act
dB re 1 µPa	decibels referenced to 1 micropascal
dB re 1 µPa @ 1 m	decibels referenced to 1 micropascal at 1 meter
dB re 1 $\mu Pa^2 \cdot s$	decibels referenced to 1 micropascal-squared seconds
dBA	decibels, A-weighted
dBP	decibels, peak sound pressure level
DLNR	Department of Land and Natural Resources
DNL	day-night level
DoD	Department of Defense
DoN	Department of the Navy
DPS	distinct population segment
EA	Environmental Assessment
EA/OEA	Environmental Assessment/Overseas Environmental Assessment
EEZ	Exclusive Economic Zone
EFH	essential fish habitat
EGTTR	Eglin Gulf Test and Training Range
EO	Executive Order
ESA	Endangered Species Act
ETTC	Eglin Test and Training Complex
FADs	fish aggregation devices
FEP	Fishery Ecosystem Plan
FMP	fishery management plan
FR	Federal Register
FTS	flight termination system
GHG	greenhouse gas
GI	gastrointestinal
GPS	Global Positioning System
GWP	global warming potential
HAPC	habitat area of particular concern
HARM	High-Speed Anti-Radiation Missile

HRC	Hawaii Range Complex
HSTT EIS/OEIS	*Hawaii Southern California Training and Testing Environmental Impact Statement/Overseas Environmental Impact Statement*
Hz	hertz
IADS	integrated air defense system
IHA	Incidental Harassment Authorization
INS	internal navigation system
ITS	Incidental Take Statement
JASSM	Joint Air-to-Surface Stand-Off Missile
JASSM-ER	Joint Air-to-Surface Stand-Off Missile-Extended Range
JDAM	Joint Direct Attack Munition
kg	kilograms
kHz	kilohertz
lb	pounds
LJDAM	Laser Joint Direct Attack Munition
LOA	letter of agreement
LRASM	Long Range Anti-Ship Missile
LTO	landings and take-off
m	meters
M	animal mass based on species (kilograms)
MALD	Miniature Air Launched Decoy
MALD-J	Miniature Air Launched Decoy–Jamming
MBTA	Migratory Bird Treaty Act
mg/L	milligrams per liter
MMPA	Marine Mammal Protection Act
MSA	Magnuson Stevens Act
MSL	mean sea level
MWR	Morale, Welfare and Recreation
N_2O	nitrous oxide
NAAQS	National Ambient Air Quality Standards
NAS	Naval Air Station
NAWC-AD	Naval Air Warfare Center - Aircraft Division
NEI	National Emissions Inventory
NEPA	National Environmental Policy Act
NEW	net explosive weight
NHPA	National Historic Preservation Act of 1966
NM^2	square nautical miles
NMFS	National Marine Fisheries Service
NM	nautical miles
NO	nitric oxide
NO_2	nitrogen dioxide
NOAA	National Oceanic and Atmospheric Administration
NOTAM	Notice to Airmen
NOTMAR	Notice to Mariners
NO_X	nitrogen oxides
NRHP	National Register of Historic Places
NRIS	National Register Information System
OPAREA	Operating Area
PA	Programmatic Agreement
Pb	lead
PBX	plastic (polymer) bonded explosive
PBXN	plastic (polymer) bonded explosive
pH	potential of hydrogen (a measure of acidity)
PM	suspended particulate matter
PM_{10}	particulates less than or equal to 10 microns in diameter

$PM_{2.5}$	fine particulate matter less than or equal to 2.5 microns in diameter
PMRF	Pacific Missile Range Facility
psi	pounds per square inch
psi·msec	pounds per square inch per millisecond
PTS	permanent threshold shift
RDX	research department explosive
ROI	region of influence
SAR	Stock Assessment Report
SDB	Small Diameter Bomb
SEL	sound exposure level
SF_6	sulfur hexafluoride
SHPO	State Historic Preservation Officer
SO_2	sulfur dioxide
SO_x	sulfur oxides
SPL	sound pressure level
TDY	temporary duty
Tg	teragrams (1 million metric tons or 1 billion kilograms)
TLA	Temporary Lodging Allowance
TM	telemetry
TNT	2,4,6-trinitrotoluene
TTS	temporary threshold shift
UNESCO	United Nations Educational, Scientific and Cultural Organization
USACHPPM	United States Army Center for Health Promotion and Preventive Medicine
USC	United States Code
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
UTTR	Utah Test and Training Range
UXO	unexploded ordnance
VOC	volatile organic compound
W-188	Warning Area 188
WPRFMC	Western Pacific Regional Fishery Management Council
WSEP	Weapon Systems Evaluation Program

This page is intentionally blank.

1.0 PURPOSE AND NEED FOR ACTION

1.1 Introduction

The U.S. Air Force proposes to conduct operational evaluations of live (explosive) long range strike weapons and other live (explosive) and inert (nonexplosive) munitions. Missions are planned to begin in October 2016 and continue during the summer for the following five years. This Environmental Assessment/Overseas Environmental Assessment (EA/OEA) analyzes and presents the potential environmental consequences associated with the conduct of live ordnance deployment in a location with adequate test capacity and instrumentation.

The 86th Fighter Weapons Squadron (86 FWS) is the test execution organization under the 53rd Wing for all Weapon Systems Evaluation Program (WSEP) deployments. The 86 FWS is the only squadron that is provided with operational allocations of weapons outside the typical training weapon allocations granted to other units. WSEP objectives are to evaluate air-to-ground and maritime weapon employment data, evaluate tactics, techniques, and procedures in an operationally realistic environment and to determine the impact of tactics, techniques, and procedures on combat Air Force training. To meet these objectives, weapon allocations for WSEP operations are based on actual reports received from units in the field regarding the types of issues or threats they are experiencing in combat. Prior to attending a WSEP evaluation, most pilots and weapon systems officers have only dropped weapons in simulators or used an aircraft's simulation mode. On average, half of the participants in each unit drop an actual weapon for the first time during a WSEP evaluation. Consequently, WSEP is the last opportunity for squadrons to receive operational training and evaluations before they deploy.

The Department of the Air Force (Air Force), along with the Department of the Navy (DoN) as a cooperating agency, has prepared this EA/OEA in accordance with the National Environmental Policy Act (NEPA), as implemented by the Council on Environmental Quality (CEQ) regulations (40 Code of Federal Regulations [CFR] 1500–1508) and Air Force regulations for implementing NEPA procedures (32 CFR 989), and Executive Order (EO) 12114, *Environmental Effects Abroad of Major Federal Actions*.

1.2 Location of the Proposed Action

The Air Force completed a detailed screening process to identify a suitable location to conduct the Proposed Action. After comparing all possible ranges against the selection standards outlined in Section 2.2, only one location was identified that would meet the operational requirements and evaluation objectives and satisfy the purpose and need of the Proposed Action. Therefore, Long Range Strike WSEP missions are proposed to take place in the Barking Sands Underwater Range Expansion (BSURE) area of the Pacific Missile Range Facility (PMRF).

The PMRF is located in Hawaii on and off the western shores of the island of Kauai and includes broad ocean areas to the north, south, and west (Figure 1.2-1). PMRF, as part of the Navy's Hawaii Range Complex (HRC), is a Major Range and Test Facility Base and, as such, supports the full spectrum of Department of Defense (DoD) test and evaluation requirements (Figure 1.2-2). PMRF is also the world's largest instrumented, multi-environment military testing and training range capable of supporting subsurface, surface, air, and space operations.

PMRF includes 1,020 square nautical miles (NM^2) of instrumented ocean areas at depths between 1,800 feet (feet) (549 meters) and 15,000 feet (4,572 meters), 42,000 NM^2 of controlled airspace, and a temporary operating area covering 2.1 million NM^2 of ocean area. The BSURE provides over 80 percent of PMRF's underwater scoring capability. The BSURE facilitates training, tactics, development, and test and evaluation for air, surface, and subsurface weapons systems in deep water. It provides a full spectrum of range support, including radar, underwater instrumentation, telemetry, electronic warfare, remote target command and control, communications, data display and processing, and target/weapon launching and recovery facilities.

Figure 1.2-1. Regional Location for the Proposed Action

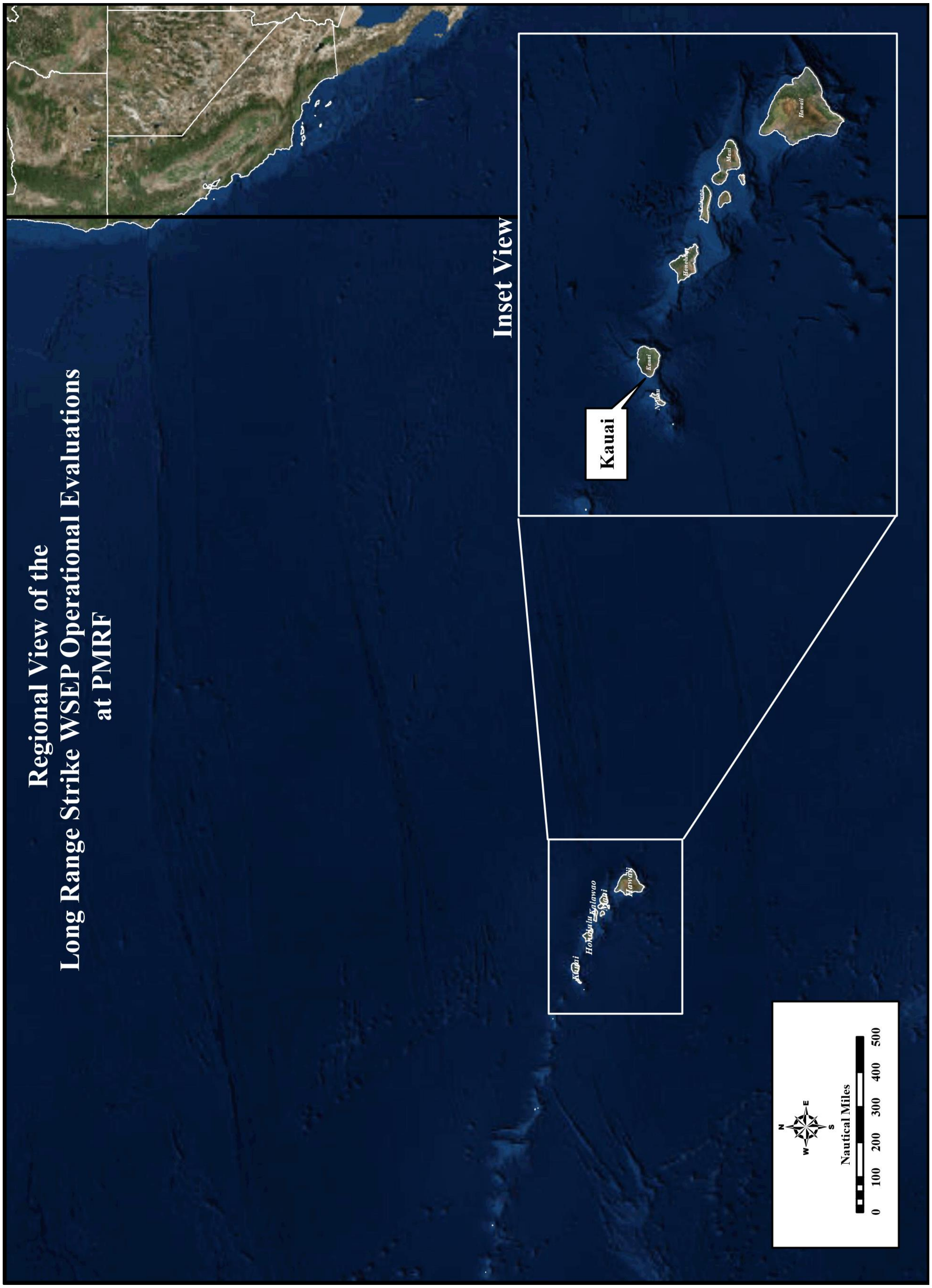
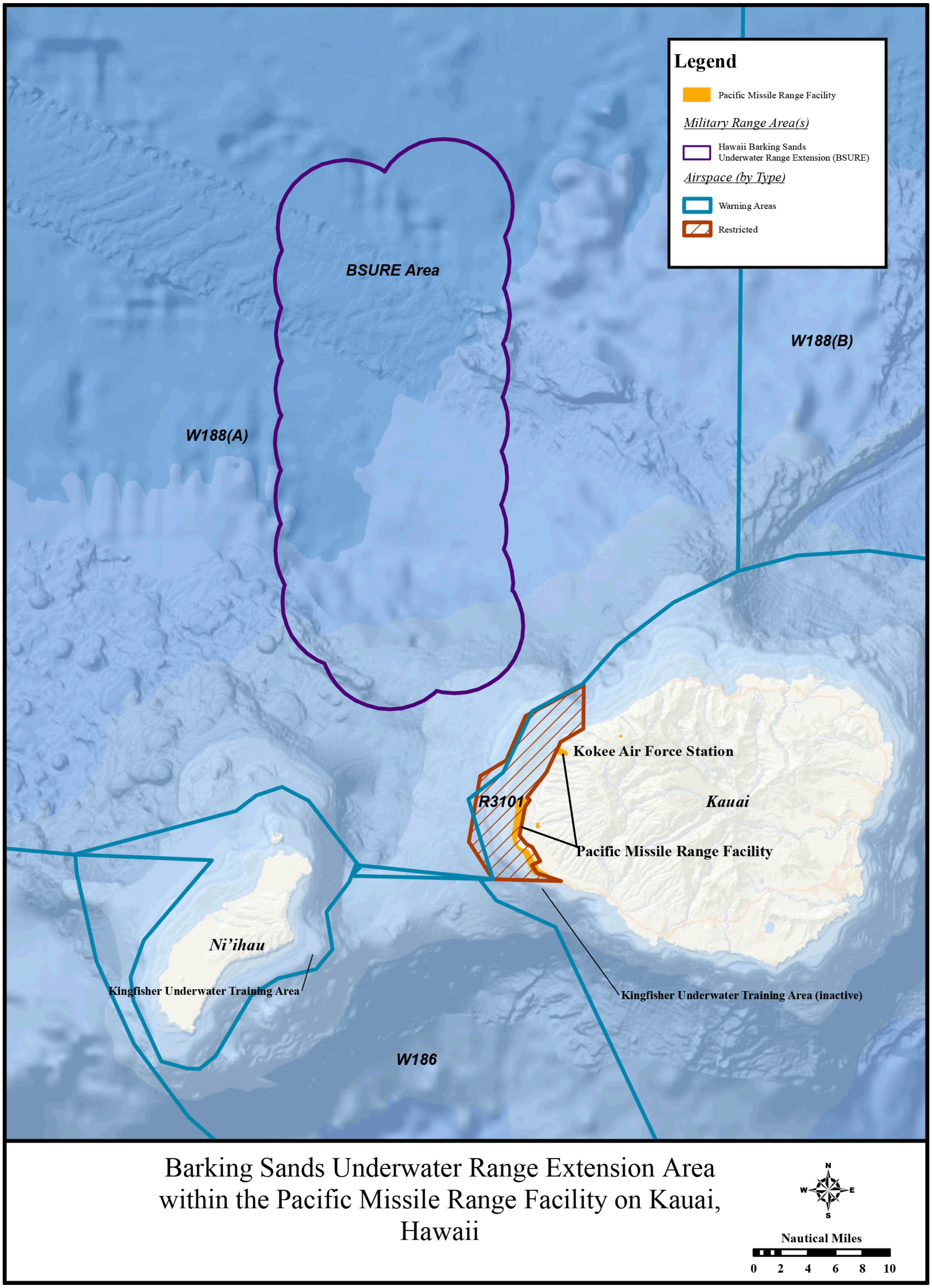


Figure 1.2-2. Pacific Missile Range Facility on Kauai, Hawaii



1.3 Purpose of and Need for the Proposed Action

The purpose of the Proposed Action is to authorize the 86 FWS to conduct operational evaluations of long range strike weapons and other munitions as part of Long Range Strike WSEP operations. Weapons include the Joint Air-to-Surface Stand-Off Missile (JASSM), JASSM-Extended Range (JASSM-ER), Small Diameter Bomb-I/II (SDB-I/II), High-Speed Anti-Radiation Missile (HARM), Joint Direct Attack Munition (JDAM), Laser JDAM (LJDAM), Miniature Air Launched Decoy (MALD), and MALD-Jamming (MALD-J). As a military readiness activity, units that participate in WSEP activities are provided a final opportunity to shoot actual weapons before deploying into combat.

The need for the Proposed Action is to properly train units to execute requirements within Designed Operational Capability Statements, which describe units' real-world operational expectations in a time of war. The munitions associated with the Proposed Action are not part of a unit's typical training allocations, and without WSEP operations, pilots would be dropping these weapons for the first time in combat.

1.4 Scope of Environmental Analysis

This EA/OEA includes an analysis of potential environmental impacts associated with the Proposed Action and the No Action Alternative. The region of influence (ROI) for this analysis is primarily in Warning Area 188A (W-188A) in the PMRF, which includes approximately 42,000 NM^2 of controlled airspace and associated waters of the Pacific Ocean, within which lies 1,020 NM^2 of BSURE instrumented underwater range. The underwater tracking system in BSURE begins 9 NM (17 kilometers) from the north shore of Kauai and extends out to 50 NM (93 kilometers) from shore. Long Range Strike WSEP missions would employ live (explosive) and inert (nonexplosive) weapons with long flight paths that require large areas of airspace and conclude with weapon impact on the water surface within the BSURE instrumented range. Detonations would occur for live weapon releases. The Proposed Action does not require beddown of any aircraft, as mission aircraft would originate from Air Force installations, such as Dyess Air Force Base (AFB), Texas; Ellsworth AFB, South Dakota; and Barksdale AFB, Louisiana, among others. Under the Proposed Action, there would be no ground-based activities requiring the use of any land portions on Kauai, and no construction of any facilities on PMRF would be required. All aspects and associated impacts from Long Range Strike WSEP missions would occur over open ocean areas.

1.5 Related Environmental Documentation

Environmental documents for similar programs, projects, and installations within the scope of this EA/OEA that have undergone environmental review for NEPA compliance include the following:

- *Hawaii-Southern California Training and Testing Environmental Impact Statement/Overseas Environmental Impact Statement*, December 2013 – This report was prepared by the Navy and includes detailed analysis of the geographic scope associated with the Proposed Action.
- *Maritime Weapon Systems Evaluation Program Final Environmental Assessment*, June 2013 – This EA was prepared by the Air Force for the 86 FWS mission activities in the Eglin Gulf Test and Training Range (EGTTR) at Eglin, AFB. The scope of the proposed action, involving live air-to-surface ordnance deployment on water ranges, is similar to the Proposed Action for this EA/OEA.
- *Maritime Strike Operations Tactics Development and Evaluation Final Environmental Assessment*, December 2014 – This EA was prepared by the Air Force for a high-priority project within the DoD that was categorized as a joint urgent operational need for the Air Force. The

scope of the proposed action, involving live air-to-surface ordnance deployment in the EGTTR for a wider range of munitions, is similar to the Proposed Action for this EA/OEA.

- *Eglin Gulf Test and Training Range Final Environmental Assessment*, October 2015 – This EA is a programmatic update to the *2002 Eglin Gulf Test and Training Range EA* and is a culmination of all air-to-surface live and inert missions conducted by the Air Force in the EGTTR.

1.6 Relevant Laws and Regulations

The Air Force has prepared this EA/OEA in accordance with NEPA (40 CFR Parts 1500–1508 and 32 CFR Part 989; United States Code [USC] Sections 4321–4370h), which require detailed environmental analysis for major federal actions with the potential to significantly affect the quality of the human and natural environments on land ranges and within the U.S. territorial waters. For purposes of this analysis, "territorial waters" extend from shoreline seaward to 12 nautical miles (NM) (22 kilometers).

This document was also prepared in accordance with EO 12114, *Environmental Effects Abroad of Major Federal Actions,* which requires environmental documentation for effects to resources seaward of U.S. territories. As defined in this document, nonterritorial waters extend beyond 12 NM (22 kilometers). The action affects resources that utilize both territorial and nonterritorial waters.

In addition to NEPA and EO 12114, this document complies with a variety of other environmental regulations. The following subsections summarize the environmental requirements most relevant to this EA/OEA.

1.6.1 Marine Mammal Protection Act

The Marine Mammal Protection Act (MMPA) established, with limited exceptions, a moratorium on the "taking" of marine mammals in waters or on lands under U.S. jurisdiction. The act further regulates "takes" of marine mammals in the high seas by vessels or persons under U.S. jurisdiction. The National Defense Authorization Act of fiscal year 2004 (Public Law 108-136) amended the definition of harassment for military readiness activities. Military readiness activities, as defined in Public Law 107-314, Section 315(f), includes all training and operations related to combat and the adequate and realistic testing of military equipment, vehicles, weapons, and sensors for proper operation and suitability for combat. This definition, therefore, includes Long Range Strike WSEP activities occurring in the PMRF study area.

Accordingly, the Air Force submitted a request for an Incidental Harassment Authorization (IHA) under Section 101(a)(5)(D) of the MMPA to the National Marine Fisheries Service (NMFS) on May 12, 2016, to authorize takes of marine mammal species by Level A and Level B harassment for missions planned for October 2016. The Air Force also submitted an application for a Letter of Authorization (LOA) under Section 101(a)(5)(D) of the MMPA on June 22, 2016, for Long Range Strike WSEP mission activities planned between 2017 and 2021. NMFS issued the IHA on September 27, 2016, and it is valid from October 1, 2016, through November 30, 2016. An LOA will be issued prior to any missions conducted in 2017.

1.6.2 Endangered Species Act

The Endangered Species Act (ESA) (16 USC 1531–1543) applies to federal actions in two separate respects. First, the ESA requires that federal agencies, in consultation with the responsible wildlife agency (e.g., NMFS), ensure that proposed actions are not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of a critical habitat (16 USC 1536 [a][2]).

As part of the environmental documentation for this EA/OEA, the Air Force entered into formal consultation with NMFS because certain actions under the Proposed Action would result in a "may affect" finding for listed species or designated critical habitat under NMFS's jurisdiction. Consultation with the U.S. Fish and Wildlife Service (USFWS) was not necessary because there will be no effect to species under USFWS jurisdiction. Formal consultation began with the Air Force submitting a Biological Assessment to NMFS on June 16, 2016. Consultation ends once NMFS prepares a final Biological Opinion (BO) and issues an Incidental Take Statement (ITS), if required. NMFS issued a BO and ITS on September 29, 2016 (Consultation Number FPR-2016-9160), for October 2016 missions. A Programmatic BO will be issued prior to any missions conducted in 2017.

1.6.3 Magnuson-Stevens Fishery Conservation and Management Act

The Magnuson-Stevens Fishery Conservation and Management Act (16 USC 1801 et seq.) was enacted to conserve and restore the nation's fisheries. This act requires that NMFS and regional fishery councils describe and identify essential fish habitat (EFH) for all species that are federally managed. EFH is defined as those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity. Under the act, federal agencies must consult with NMFS regarding any activity or proposed activity that is authorized, funded, or undertaken by the agency that may adversely affect EFH. An EFH assessment was provided to NMFS's Habitat Conservation Division of the Pacific Islands Regional Office on April 19, 2016. As described in Chapter 4, no adverse effects to EFH or federally managed fisheries are anticipated from Long Range Strike WSEP mission activities. NMFS provided a response letter on May 19, 2016, with five conservation recommendations for the Air Force to consider that would minimize potential adverse impacts to EFH. The Air Force submitted a response to each conservation recommendation in a letter dated June 22, 2016, and supplemental responses in a letter dated August 30, 2016. All agency correspondence is included in Appendix A, *Agency Correspondence and Consultation*.

1.6.4 Coastal Zone Management Act

The Coastal Zone Management Act (CZMA) provides assistance to states, in cooperation with federal and local agencies, for developing land and water use programs for their respective coastal zones. The CZMA requires all federal agencies to conduct activities that affect any land or water use or natural resource of the coastal zone in a manner consistent with, to the maximum extent practicable, the enforceable policies of the National Oceanic and Atmospheric Administration (NOAA)-approved state management program. Given that the Proposed Action would occur over 40 NM offshore, outside state waters, and will not impact any coastal resources, the activities analyzed in this document do not fall under the purview of the CZMA.

1.6.5 Migratory Bird Treaty Act

The Migratory Bird Treaty Act (MBTA) was enacted to ensure the protection of shared migratory bird resources. The MBTA prohibits the intentional take, possession, import, export, transport, selling, purchase, or barter, or offering for sale, purchase, or barter, of any migratory bird or its egg, part, or nest, except as authorized under a valid permit.

Under this rule, the Air Force is still required under NEPA to consider the environmental effects of its actions and assess the adverse effects of military readiness activities on migratory birds. If it is determined that the Proposed Action may result in a significant adverse effect on a population of a migratory bird species, the Air Force will consult with USFWS to develop and implement appropriate conservation measures to minimize or mitigate these effects. Based on the analysis provided in Chapter 0, which shows that no adverse effects to migratory bird individuals or populations are anticipated, the Air Force is not planning consultations with USFWS under this act.

1.6.6 Clean Water Act

The Clean Water Act, as amended in 1972, regulates point and non-point source pollutant discharges into navigable waters of the United States. The U.S. Environmental Protection Agency (USEPA) controls pollutant discharges through the National Pollutant Discharge Elimination System permit program. No point or non-point sources result from the Proposed Action; therefore, it is not anticipated that a permit would be required under the Clean Water Act.

1.6.7 National Historic Preservation Act of 1966 (as amended)

The National Historic Preservation Act of 1966 (NHPA) was enacted to set federal policy for managing and protecting significant historic properties for both submerged and terrestrial resources. Federal agencies must identify historic properties and consult with the Advisory Council on Historic Preservation and State Historic Preservation Officer (SHPO). Section 106 of the NHPA requires that federal agencies analyze the impacts of federal activities on historic properties or cultural resources included in or eligible for inclusion in the National Register of Historic Places (NRHP). Section 110 of the NHPA requires that federal agencies inventory any cultural resources that are located on their property or within their control and to nominate those found to be significant for inclusion in the NRHP. The Air Force submitted a letter to the Hawaii State Historic Preservation Division on March 31, 2016, indicating that Long Range Strike WSEP activities would result in a “no historic properties affected” determination in accordance with Section 106 implementing regulations under 36 CFR 800.4(d)(1). The Air Force received concurrence from the Hawaii State Historic Preservation Division on April 20, 2016.

1.6.8 Abandoned Shipwreck Act of 1987

The Abandoned Shipwreck Act of 1987 gives the title and jurisdiction over historic shipwrecks to the federal government, extending to the Exclusive Economic Zone (EEZ). The EEZ extends 200 NM from the shoreline and is under the jurisdiction of the Department of the Interior. This applies even if the ship is within state waters. Before engaging in an activity that may negatively affect a shipwreck, this act requires consideration of the effect the activity may have on submerged resources.

1.7 Cooperating Agencies

The Air Force is the lead agency for the Proposed Action and is responsible for the scope and content of this EA/OEA. The Navy is a cooperating agency in the preparation of this EA/OEA and has provided background environmental data and information regarding the PMRF and BSURE areas. While NMFS is not officially a cooperating agency, as a regulatory authority over marine resources, NMFS reviewed and provided input on this EA/OEA. NMFS prepared a separate NEPA analysis for issuing an IHA under the MMPA for 2016 missions, while this EA/OEA will serve as NMFS’s NEPA documentation for the rule-making process to issue an LOA under the MMPA for 2017–2021 missions.

1.8 Public Notification and Review

Regulations from the CEQ (40 CFR Part 1506.6) direct agencies to involve the public in preparing and implementing the NEPA procedures. The Air Force published a Notice of Availability of the Draft EA/OEA for two days in the *Honolulu Star Advertiser* and *The Garden Island* (on July 27 and 30, 2016), for public review and initiated a 30-day comment period. The notice described the Proposed Action, solicited public comments on the Draft EA/OEA, provided dates of the public comment period, and announced that a copy of the EA/OEA would be available for review online at http://www.afcec.af.mil/index.asp. The public comment period for the Draft EA/OEA began July 27, 2016, and ended August 26, 2016. No public comments were received on the Draft EA/OEA.

1.9 Decisions to Be Made

The Air Force, in cooperation with the Navy, desires to authorize Long Range Strike WSEP mission activities from 2016 through 2021. As described in Chapter 2, two action alternatives and a No Action Alternative are considered. Following the public review period, the Air Force will consider public and agency comments received in deciding whether to (1) sign the Finding of No Significant Impact, which would allow the Proposed Action to proceed; (2) conduct additional environmental analysis by preparing a supplemental EA/OEA or an environmental impact statement; or (3) select the No Action Alternative.

1.10 Issues

For purposes of this analysis, an *issue* is an effect of a mission activity that may directly or indirectly impact physical, biological, and/or cultural environment resources. A *direct* impact is a distinguishable, evident link between an action and the potential impact, whereas an *indirect* impact may occur later in time and/or may result from a direct impact.

Potential environmental impacts of alternative actions on PMRF resource areas were identified through preliminary investigation. Resource areas eliminated from further analysis are discussed in Section 1.10.1. Resource areas identified for detailed analysis are described in Section 1.10.2, with narratives providing a summary of the preliminary screening for potential impacts.

1.10.1 Resource Areas Eliminated from Further Analysis

Resource areas identified and later eliminated from further analysis are described in the following subsections.

1.10.1.1 Environmental Justice

Environmental justice addresses the potential for a proposed federal action to cause disproportionately high and adverse health effects on minority populations or low-income populations, including children. The analysis examines the demographics of potentially affected commercial and recreational users and whether they comprise minority or low-income groups. Because all of the proposed activities occur in the BSURE area of the PMRF, where there are no minority or low-income populations present, there are no disproportionately high and adverse human health or environmental impacts from the Proposed Action on minority populations or low-income populations.

1.10.1.2 Hazardous Waste

Generally, conventional explosive ordnance testing at operational ranges does not yield hazardous waste as regulated by the Resource Conservation and Recovery Act. The solid waste exclusion contained in the Military Munitions Rule, 40 CFR 266.200, et seq., is effectively an exclusion from the definition of "hazardous waste," since only something meeting the definition of "solid waste" and several other criteria can meet the definition of "hazardous waste" (UXOINFO, 2013). Similarly, the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) does not apply directly to unexploded ordnance (UXO) at operational ranges, including "active ranges" and "inactive ranges" as defined by 40 CFR 266.201. Congress has indicated that CERCLA only applies to UXO located on ranges "other than operational ranges" (10 USC 2710). Therefore, UXO located in areas other than operational ranges is considered solid waste and not hazardous waste. The Hawaii Range Complex RSEPA addresses the subject of marine environments in the HRC, which includes PMRF.

1.10.2 Resource Areas Identified for Detailed Analysis

Potential environmental impacts of alternative actions on PMRF resource areas were identified through preliminary investigation. Resource areas identified for detailed analysis are described in the following subsections, which also summarize the preliminary screening for potential impacts.

1.10.2.1 Air Quality

Air quality, with respect to those pollutants for which the USEPA has promulgated National Ambient Air Quality Standards (NAAQS) and/or the Hawaii Department of Health Clean Air Branch has promulgated an ambient standard, was evaluated as a potential issue. Under existing conditions, the ambient air quality in the entire state of Hawaii is classified as in attainment for the federal and state ambient air quality standards established for all criteria pollutants. The installations identified as potential outbases are typically characterized by numerous aircraft takeoffs and landings each day. It is assumed landing and takeoff activities associated with aircraft operations that support Long Range Strike WSEP missions would fit within the existing operational tempos and Air Installation Compatible Use Zone (AICUZ) evaluated levels for each outbase installation. Therefore, the analysis in this EA/OEA focuses on the potential increase in air emissions generated from munitions use and aircraft operations within the airspace units associated with the BSURE area at PMRF.

1.10.2.2 In-Air Noise Impacts to the Public

In-air noise impacts to the public from detonations and aircraft operations are addressed in the analysis. The Air Force would establish a safety footprint around the target area that encompasses all potentially harmful in-air noise. Members of the public would not be allowed to enter the safety footprint. Additionally, mission support personnel would likewise maintain a safe distance from the target area. The distances between the safety footprint boundaries and noise contours from populated areas and likelihood of impacts is discussed.

1.10.2.3 Airspace

The Proposed Action would occur in designated special use airspace areas established for the purpose of military testing and training. The Proposed Action would be conducted in accordance with established Navy procedures for air-to-surface weapon release missions in the PMRF and through coordination with the Federal Aviation Administration and other scheduling authorities. This EA/OEA will analyze only the PMRF portions that coincide primarily with W-188A and W-188B.

1.10.2.4 Public Safety

The issue of safety pertains to hazards from the Proposed Action to military personnel and the public. Such hazards include the delivery of live ordnance, live detonations, and the possibility of UXO from munitions that fail to detonate. The analysis identifies the potential safety hazards and also discusses restricted access areas established by the Air Force to ensure the safety of the public.

1.10.2.5 Socioeconomics

Potential socioeconomic impacts are closely related to the restricted access issue described above. Periodic closure of portions of the Pacific Ocean could potentially impact the availability of these areas for commercial and recreational activities, including commercial and recreational fishing and vessel traffic, whale watching, and scientific research. While the offshore waters in which BSURE is located are not restricted from public use, their use is limited by the fact that they are within a warning area, W-188A, where military training exercises that are potentially hazardous to the public occur on a continuous basis. The analysis identifies the potential impact additional closures within BSURE would have on these recreational and commercial activities.

1.10.2.6 Cultural Resources

Cultural resources within the deepwater areas offshore of PMRF would typically consist of shipwrecks. Locations of known shipwrecks and other submerged cultural resources are identified and potential impacts from debris and in-water detonations are assessed based on the proximity to the proposed weapon impact location.

1.10.2.7 Physical Resources

Physical resources, which include water and sediments, would potentially be exposed to explosive byproducts, munitions fragments, and petroleum products. Liquid, solid, and gaseous substances released into the environment from Long Range Strike WSEP missions would consist of organic and inorganic materials that may produce a chemical change or toxicological effect to the environment. Military expended materials, including munition fragments and unexploded bombs, would be a source of pollutants that would be deposited into Pacific Ocean waters and onto the seafloor.

1.10.2.8 Biological Resources

Underwater sound from detonations is the primary issue with regard to potential effects to biological resources. Analyses of potential acoustic impacts include discussions of two detonation components: physical overpressure and acoustic energy. Exposure to pressure waves or acoustic energy from underwater detonations could result in stress reactions in marine species or, in some cases, cause hearing loss/damage, physical injuries, or death. These impacts are analyzed in terms of the potential for “take,” as defined by the ESA and MMPA, of federally protected marine species (i.e., marine mammals and sea turtles) from in-water detonations of live ordnance. Direct impact to a biological resource from an inert munition or surface vessel, while theoretically possible, is unlikely.

2.0 DESCRIPTION OF PROPOSED ACTION AND ALTERNATIVES

2.1 Proposed Action

The Proposed Action is to authorize the 86 FWS to conduct operational evaluations of long range strike weapons in a location with adequate test capacity and instrumentation. This program, referred to as Long Range Strike WSEP, would primarily employ live long range strike weapons systems, along with other live and inert munitions. No land-based operations or construction activities are associated with the Proposed Action. Operations would be conducted in accordance with approved aircraft and weapons standard operating procedures and instructions.

2.1.1 Aircraft Operations

Aircraft used for munition releases would include bombers and fighter aircraft. Additional airborne assets, such as the P-3 Orion or the P-8 Poseidon, would be used to relay telemetry (TM) and flight termination system (FTS) streams between the weapons and ground stations. Other support aircraft would be associated with range clearance activities before and during the mission and air-to-air refueling operations. All weapon delivery aircraft would originate from an outbase and fly into military-controlled airspace prior to employment. The aircraft that would be participating in the Long Range Strike WSEP missions are currently bedded down at each of their respective installations and routinely conduct operational testing and training sorties from these bases. Due to long transit times between the outbase and mission location, air-to-air refueling may be conducted in W-188A, W-188B, or W-189. Bombers, such as the B-1, would deliver the weapons, conduct air-to-air refueling, and return to their originating base as part of one sortie. However, when fighter aircraft are used, the distance and corresponding transit time to the various potential originating bases would make return flights after each mission day impractical. In these cases, the aircraft would temporarily (for less than one week) park overnight at Hickam AFB and would return to their home base at the conclusion of each mission set. Multiple weapon-release aircraft would be used during each mission, each potentially releasing multiple munitions. Each Long Range Strike WSEP mission set would occur over a maximum of five consecutive days per year. Approximately 10 Air Force personnel would be on temporary duty to support each mission set. Table 2.1-1 summarizes example types of aircraft proposed to support Long Range Strike WSEP missions.

Table 2.1-1. Summary of Example Aircraft Usage During Long Range Strike WSEP Missions

Type	Example Aircraft	Purpose	Potential Outbases
Bombers	B-1, B-2, B-52	Weapon release	Ellsworth AFB, Dyess AFB, Barksdale AFB, Whiteman AFB, Minot AFB
Fighter aircraft	F-15, F-16, F-22, F-35	Weapon release, chase aircraft, range clearance	Mountain Home AFB, Nellis AFB, Hill AFB, JB Hickam-Pearl Harbor, JB Elmendorf-Richardson, JB Langley-Eustis
Refueling tankers	KC-135	Air-to-air refueling	McConnell AFB
Surveillance	P-3, P-8	TM and FTS relays	Point Mugu, NAS
Helicopters	S-61N	Range clearance, protected species surveys	PMRF
Cargo aircraft	C-130, C-26	Range clearance, protected species surveys	U.S. Coast Guard, PMRF

AFB = Air Force Base; FTS = flight termination system; JB = Joint Base; NAS = Naval Air Station; PMRF = Pacific Missile Range Facility; TM = telemetry

Aircraft flight maneuver operations and weapon release would be conducted in W-188A. Chase aircraft may be used to evaluate weapon release and track weapons. Flight operations and weapons delivery would be in accordance with published Air Force directives and weapon operational release parameters, as well as all applicable Navy safety regulations and criteria established specifically for PMRF. Aircraft supporting Long Range Strike WSEP missions would primarily operate at high altitudes, only flying below 3,000 feet for a limited time as needed for escorting nonmilitary vessels outside the hazard area or for monitoring the area for protected marine species (e.g., marine mammals, sea turtles). Protected marine species aerial surveys would be temporary and would focus on an area surrounding the weapon impact point on the water. A detailed description of protected marine species clearance procedures is included in Appendix A. Range clearance procedures for each mission would cover a much larger area for human safety. Weapon release parameters would be conducted as approved by PMRF Range Safety. Daily mission briefs would specify planned release conditions for each mission. Aircraft and weapons would be tracked for time, space, and position information. The 86 FWS test director would coordinate with the PMRF Range Safety Officer, Operations Conductor, Range Facility Control Officer, and other applicable mission control personnel for aircraft control, range clearance, and mission safety. Figure 2.1-1 shows a photograph taken by a chase aircraft of a JASSM being released and in flight.

Figure 2.1-1. Joint Air-to-Surface Stand-Off Missile (JASSM) Released

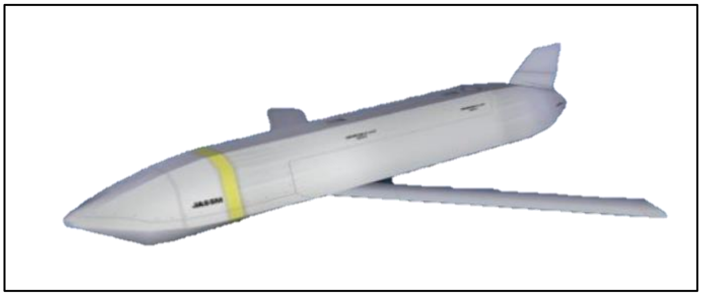
2.1.2 Description of Long Range Strike WSEP Munitions

Long Range Strike WSEP missions would release live (explosive) and inert (nonexplosive) JASSM/JASSM-ER, SDB-I/II, HARM, JDAM/LJDAMs, and MALD /MALD-J. A description of each munition is included in the following subsections.

2.1.2.1 Joint Air-to-Surface Stand-off Missile/Joint Air-to-Surface Stand-Off Missile-Extended Range (JASSM/JASSM-ER)

The JASSM (Figure 2.1-2) is a stealthy precision cruise missile designed for launch outside area defenses against hardened, medium-hardened, soft, and area type targets. The JASSM has a range of more than 200 NM (370 kilometers) and carries a 1,000-pound warhead with approximately 300 pounds of 2,4,6-trinitrotoluene (TNT) equivalent net explosive weight (NEW). The specific explosive used is AFX-757, a type of plastic bonded explosive (PBX). The weapon has the capability to fly a preprogrammed route from launch to a target, using Global Positioning System (GPS) technology and an internal navigation system (INS) combined with a Terminal Area Model when available. Additionally, the weapon has a Common Low Observable Auto-Routing function that gives the weapon the ability to find the route that best utilizes the low observable qualities of the JASSM. In either case, these routes can be modeled prior to weapon release. The JASSM-ER has additional fuel and a different engine for a greater range than the JASSM (500 NM [926 kilometers]) but maintains the same functionality of the JASSM.

Figure 2.1-2. Joint Air-to-Surface Stand-Off Missile (JASSM)



2.1.2.2 Small Diameter Bomb-I/Small Diameter Bomb-II (SDB-I/SDB-II)

The SDB I (Figure 2.1-3) is a 250-pound air-launched GPS-INS guided weapon for fixed soft to hardened targets. SDB II (Figure 2.1-4) expands the SDB I capability with network enabling and uses a tri-mode sensor infrared, millimeter, and semi-active laser to attack both fixed and movable targets. Both munitions have a range of up to 60 NM (111 kilometers). The SDB-I contains 37 pounds of TNT-equivalent NEW, and the SDB-II contains 23 pounds NEW. The explosive used in both SDB-I and SDB-II is AFX-757.

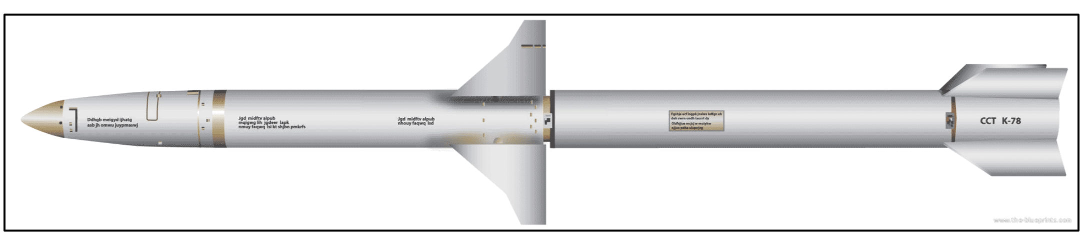
Figure 2.1-3. Small Diameter Bomb-I (SDB-I)

Figure 2.1-4. Small Diameter Bomb-II (SDB-II)

2.1.2.3 High-Speed Anti-Radiation Missile (HARM)

The HARM (Figure 2.1-5) is a supersonic air-to-surface missile designed to seek and destroy enemy radar-equipped air defense systems. The HARM has a proportional guidance system that homes in on enemy radar emissions through fixed antenna and seeker head in the missile nose. It has a range of up to 80 NM (148 kilometers) and contains 45 pounds of TNT-equivalent NEW. The explosive used is PBXN-107.

Figure 2.1-5. High-Speed Anti-Radiation Missile (HARM)



2.1.2.4 Joint Direct Attack Munition/Laser Joint Direct Attack Munition (JDAM/LJDAM)

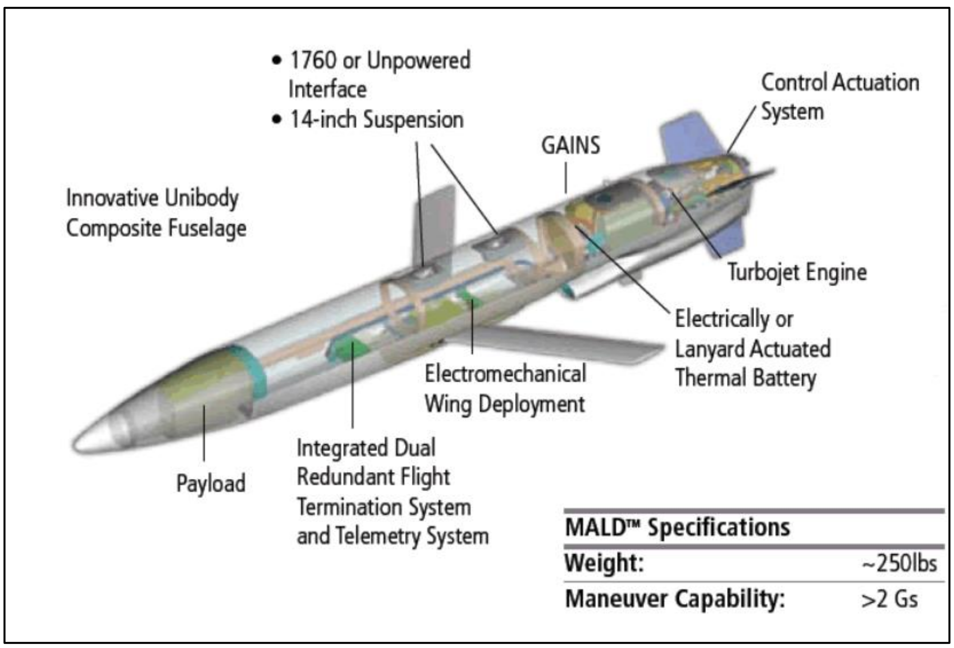
The JDAM (Figure 2.1-6) is a smart GPS-INS weapon that uses an unguided gravity bomb and adds a guidance and control kit, converting it to a precision-guided munition. The LJDAM variant adds a laser sensor to the JDAM permitting guidance to a laser designated target. Both JDAM and LJDAM contain 192 pounds of TNT-equivalent NEW with multiple fusing options, with detonations occurring upon impact or with up to a 10-millisecond delay.

Figure 2.1-6. Joint Direct Attack Munition (JDAM)

2.1.2.5 Miniature Air Launched Decoy (MALD/MALD-J)

The MALD (Figure 2.1-7) is an air-launched, expendable decoy that will provide the Air Force the capability to simulate, deceive, decoy, and saturate an enemy's threat integrated air defense system (IADS). The MALD production has recently transitioned to include the MALD-J variant with the same decoy capability of the MALD plus the addition of jamming IADS. The MALD and MALD-J have ranges up to 500 NM (926 kilometers) to include a 200-NM (370-kilometer) dash with a 30-minute loiter mode. It has no warhead and, therefore, no detonation upon impact with the water surface would occur.

Figure 2.1-7. Miniature Air Launched Decoy (MALD and MALD-J)



2.1.3 Schedule and Mission Procedures

Initial phases of Long Range Strike WSEP operations are proposed for October 2016 and would only consist of releasing one live JASSM/JASSM-ER and eight SDB-I/II in military controlled airspace. All live releases for 2016 would result in surface detonations.

Follow-on evaluations planned for 2017 through 2021 would add the employment of live and inert HARM, JDAM, and MALD, in addition to continued evaluation of JASSM/JASSM-ER and SDB-I/II. Releases of live ordnance associated with 2017–2021 missions would result in either airbursts or surface or subsurface detonations (10-foot [3-meter] depth).

A typical mission day would consist of pre-mission checks, safety review, crew briefings, weather checks, clearing airspace, range clearance, mitigations/monitoring efforts, and other military protocols prior to launch of weapons. These standard operating procedures are usually done in the morning, and range time may begin in late morning once all checks are complete and approval is granted from range control. The range would be closed to the public for a maximum of four hours per mission day.

Each long range strike weapon (JASSM/JASSM-ER, SDB-I/II, HARM, MALD/MALD-J) would be released in W-188A and would follow a given flight path with programmed GPS waypoints to mark its course in the air. Long range strike weapons would complete their maximum flight range (up to 500-NM distance for JASSM-ER) at an altitude of approximately 18,000 feet mean sea level (MSL) and terminate at a specified location for scoring of the impact. The cruise time would vary among the munitions, but would be about 45 minutes for JASSM/JASSM-ER and 10 minutes for SDB-I/II. Similarly, the time frame between employment of successive munitions would vary, but releases could be spaced by a maximum of one hour to account for the JASSM cruise time. The routes and associated safety profiles would be contained within W-188A boundaries. The objective of the route designs is to complete full-scale evasive maneuvers that avoid simulated threats and would, therefore, not consist of a standard "paper clip" or regularly shaped route. The final impact point on the water surface would be programmed into the munitions for weapons scoring and evaluations. The JDAM/LJDAM munitions would also be set to impact at the same point on the water surface.

All missions would be conducted in accordance with applicable flight safety, hazard area, and launch parameter requirements established for PMRF. A weapon hazard region would be established, with the size and shape determined by the maximum distance a weapon could travel in any direction during its descent. The hazard area is typically adjusted for potential wind speed and direction, resulting in a maximum composite safety footprint for each mission (each footprint boundary is at least 10 NM from the Kauai coastline). This information is used to establish a Launch Exclusion Area and Aircraft Hazard Area. These exclusion areas must be verified to be clear of all nonmission and nonessential vessels and aircraft before live weapons are released. In addition, a buffer area must also be clear on the water surface so that vessels do not enter the exclusion area during the launch window. Prior to weapon release, a range sweep of the hazard area would be conducted by participating mission aircraft or other appropriate aircraft, potentially including S-61N helicopter, C-26 aircraft, fighter aircraft (F-15E, F-16, F-22), or the Coast Guard's C-130 aircraft.

Surface vessels may be used to supplement range clearing activities. PMRF has used small water craft docked at the Port Allen public pier to keep nearshore areas clear of tour boats for some mission launch areas. However, for missions with large hazard areas that occur far offshore from Kauai, it would be impractical for these smaller vessels to conduct range clearance activities. The composite safety footprint weapons associated with Long Range Strike WSEP missions is anticipated to be rather large; therefore, it is likely that range clearing activities would be conducted solely by aircraft.

The Range Facility Control Officer is responsible for establishing hazard clearance areas, directing clearance and surveillance assets, and reporting range status to the Operations Conductor. The Control Officer is also responsible for submitting all Notices to Airmen (NOTAMs) and Notices to Mariners (NOTMARs), and for requesting all Federal Aviation Administration (FAA) airspace clearances. In addition to the human safety measures described above, protected species surveys are carried out before and after missions, as summarized in Section 3.8, *Biological Resources*.

2.2 Alternatives Carried Forward for Detailed Analysis

NEPA's implementing regulations provide guidance on the consideration of alternatives to a federal agency's proposed action and require rigorous exploration and objective evaluation of reasonable alternatives. Only those alternatives determined to be reasonable and meet the purpose and need require detailed analysis. The 86 FWS identified a list of selection standards that would support the operational evaluations of long range strike weapons and meet overall WSEP objectives. Potential alternatives that meet the purpose and need of the Proposed Action were evaluated against the following selection standards:

<u>Airspace requirements</u> – In order to support a maximum 500-NM range for long range strike weapons included in the Proposed Action, the 86 FWS requires a range with an airspace unit large enough to contain the full-scale maneuvers and associated safety footprints.

<u>Fully instrumented range</u> – Long range strike WSEP missions require full flight termination system and telemetry support to track all munitions. Test objectives also require GPS jamming capabilities for MALD-J evaluations.

<u>Weapon impact scoring</u> – End-to-end Long Range Strike WSEP evaluations include capturing weapon impact and scoring data to determine munition performance.

<u>Range flexibility</u> – Range should accommodate all operational aspects of releasing live long range weapons, in sufficient quantities and employment scenarios. This includes the availability of assets within the range to meet safety requirements and successfully execute operations consistent with range standard operating procedures.

Comparing the capabilities of multiple DoD installations throughout the U.S. with the selection standards listed above, the BSURE and associated airspace block W-188A of the PMRF was the only location that satisfied these requirements and met the purpose and need for the Proposed Action. Two action alternatives were identified to be analyzed in this EA/OEA and are based on the necessary number of releases and fusing options, resulting in multiple detonation scenarios. Under the two action alternatives, the level of operations would provide the intended level of evaluation, including a number of replicate operations sufficient for an acceptable statistical confidence level regarding munitions capabilities.

Fusing options for munitions have varying implications, as they will determine where detonations will occur and how resources will be impacted. Detonation scenarios that correspond to the potential fusing options (height of burst, point detonation, and time-delayed fuzing) are airburst, surface, and subsurface detonations, each of which would result in ever-increasing levels of underwater sound intensity. Thus, the amount of underwater sound, which can expose marine resources to varying levels of acoustic impacts, can be managed by selecting the detonation scenario of specific munitions. Subsurface detonations would generate the most underwater sound, thereby resulting in greater acoustic impacts to marine resources. Therefore, Alternative 1 includes the necessary number of munitions, with the maximum time-delayed fusing for ordnance with that capability, resulting in subsurface detonations. Alternative 2 includes the same number of munitions but does not include a time-delayed fusing option for the same munitions analyzed under Alternative 1, such that there would be no subsurface detonations. For either action alternative, mitigation measures developed as part of the ESA and MMPA consultation processes will be employed to avoid any harm to federally protected marine species. A No Action Alternative is also analyzed.

2.2.1 No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur. Long Range Strike WSEP missions would not be conducted and no live or inert releases of munitions related to Long Range Strike WSEP would occur at PMRF. The No Action Alternative would not meet the purpose and need for the Proposed Action; however, as required by NEPA, the No Action Alternative is carried forward for analysis in this EA/OEA and provides a baseline for measuring the environmental consequences of the action alternatives.

2.2.2 Alternative 1 (Preferred Alternative)

Under Alternative 1, the 86 FWS would be authorized to conduct operational evaluations of long range strike weapons in a location with adequate test capacity and instrumentation. This operational test program would utilize multiple types of aircraft (Table 2.1-1) and weapons systems, employing them under all possible fusing options and detonation scenarios. As described in Section 2.1, operations would be conducted in approved aircraft and weapon standard procedures and instructions.

Alternative 1 provides the intended level of evaluation, including a number of replicate operations sufficient for an acceptable statistical confidence level regarding munitions capabilities. Immediate evaluations for JASSM/JASSM-ER and SDB I are needed; therefore, they are the only munitions being proposed for 2016 missions, currently set for October. Weapon release parameters for 2016 missions would involve a B-1 bomber releasing one live JASSM and fighter aircraft, such as F-15, F-16, or F-22, releasing live SDB-I. Up to four SDB-I munitions would be released simultaneously, similar to a ripple effect, each hitting the water surface within a few seconds of each other; however, the SDB-I releases would occur separate from the JASSM. All releases would occur on the same mission day, with the following day reserved as a backup day.

Follow-on years (2017 – 2021) would add evaluations of HARM, JDAM/LJDAM, and MALD/MALD-J, along with JASSM/JASSM-ER and SDB I/II. Similar to what is proposed for 2016 missions, up to four SDB I/II munitions could be released simultaneously, such that each ordnance would hit the water surface within a few seconds of each other. It is not known how many weapon releases or what combination of munitions would be released each day. However, aside from the SDB-I/II releases, all other weapons would be released separately, impacting the water surface at different times. There would be a total of five mission days per year during the time frame of 2017 to 2021.

Table 2.2-1 shows live (explosive) and inert (nonexplosive) munition releases proposed annually at PMRF from 2016 through 2021 under Alternative 1.

Table 2.2-1. Proposed Munitions at PMRF Under Alternative 1 (2016-2021)

Type of Munition	Live or Inert	NEW (lb)	Type of Aircraft	Detonation Scenario	Number of Proposed Releases					
					2016	2017	2018	2019	2020	2121
JASSM / JASSM-ER	Live	300	Bomber	Surface	1	6	6	6	6	6
SDB-I	Live	37	Bomber, Fighter	Surface	8	30	30	30	30	30
SDB-II	Live	23	Bomber, Fighter	Surface	0	30	30	30	30	30
HARM	Live	45	Fighter	Surface	0	10	10	10	10	10
JDAM / LJDAM	Live	192	Bomber, Fighter	Subsurface[1]	0	30	30	30	30	30
MALD / MALD-J	Inert	N/A	Fighter	N/A	0	4	4	4	4	4

HARM = High-Speed Anti-Radiation Missile; JDAM = Joint Direct Attack Munition; lb = pounds; LJDAM = Laser Joint Direct Attack Munition; MALD = Miniature Air Launched Decoy; PMRF = Pacific Missile Range Facility; SDB = Small Diameter Bomb

1. Assumes a 10-millisecond time-delayed fuse resulting in detonation occurring at an approximate 10-foot water depth.

As shown in Table 2.2-1, a variety of aircraft would conduct weapon releases. Additional assets would be utilized for range clearance, relaying telemetry and flight termination system streams between the weapon and ground stations, and conducting air-to-air refueling. Multiple weapon-release aircraft would be used during a single mission, each potentially releasing multiple munitions successively. Missions proposed for 2016 would occur in October, while 2017–2021 missions would occur during the summer. Each mission set during 2017 through 2021 would last up to five consecutive days, with a range time of approximately four hours per day. As discussed in Section 2.1.3, each weapon would be released in W-188A and would complete their maximum flight range at an altitude of approximately 18,000 feet MSL and terminate at a specified location on the water surface to be acoustically scored and evaluated using the BSURE hydrophone system. The final impact point for all munitions is within the BSURE area, approximately 44 NM (81 kilometers) offshore of Kauai in approximate water depth of 15,240 feet (4,645 meters) as shown in Figure 2.3-1.

2.2.1 Alternative 2

Alternative 2 would authorize the same number of munitions as proposed under Alternative 1. However fusing options would not include a 10-millisecond time delay for JDAMs, which would result in surface detonations as opposed to subsurface detonations (Table 2.2-2). All munitions would be released and evaluated under the same scenarios and criteria, impacting within the same location on the water surface. Aircraft operations and range clearing activities would be the same as described above. This alternative still meets operational requirements but would potentially generate less underwater sound and, thus, potentially reduce acoustic impacts to protected marine species.

Table 2.2-2. Proposed Munitions at PMRF Under Alternative 2 (2016-2021)

Type of Munition	Live or Inert	NEW (lb)	Type of Aircraft	Detonation Scenario	Number of Proposed Releases					
					2016	2017	2018	2019	2020	2121
JASSM / JASSM-ER	Live	300	Bomber	Surface	1	6	6	6	6	6
SDB-I	Live	37	Bomber, Fighter	Surface	8	30	30	30	30	30
SDB-II	Live	23	Bomber, Fighter	Surface	0	30	30	30	30	30
HARM	Live	45	Fighter	Surface	0	10	10	10	10	10
JDAM/LJDAM	Live	192	Bomber, Fighter	Surface	0	30	30	30	30	30
MALD/MALD-J	Inert	N/A	Fighter	N/A	0	4	4	4	4	4

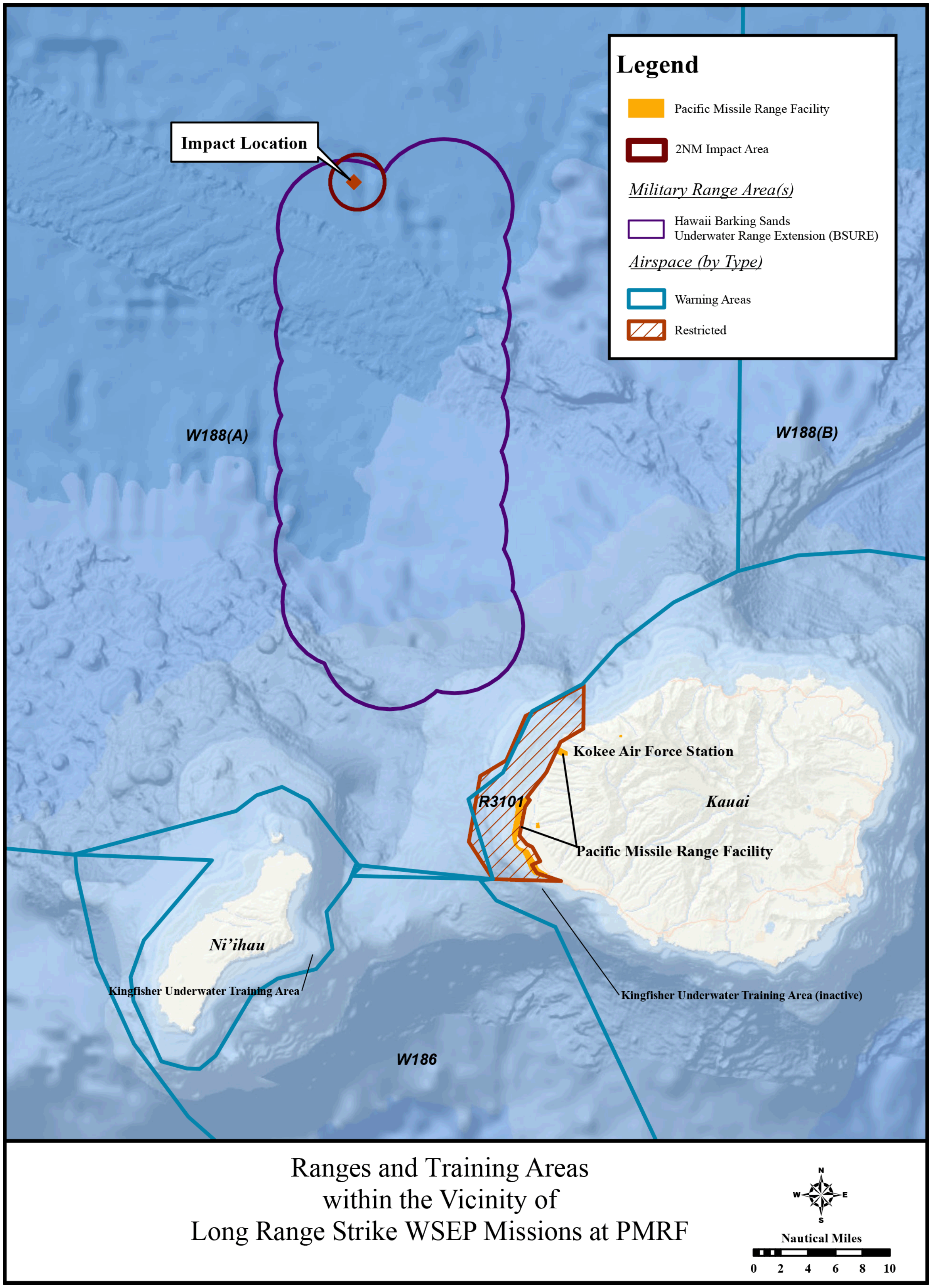
HARM = High-Speed Anti-Radiation Missile; JDAM = Joint Direct Attack Munition; lb = pounds; LJDAM = Laser Joint Direct Attack Munition; MALD = Miniature Air Launched Decoy; PMRF = Pacific Missile Range Facility; SDB = Small Diameter Bomb

2.3 Alternatives Considered but Not Carried Forward for Detailed Analysis

As stated above, when evaluating potential locations that could support operational evaluations of long range strike weapons while meeting overall WSEP objectives, the 86 FWS investigated existing capabilities for multiple DoD installations to determine which locations could adequately support these types of missions. The following ranges were identified but rejected as possible locations to conduct Long Range Strike WSEP missions and meet the purpose and need for the Proposed Action:

- Eglin Gulf Test and Training Range/Eglin Test and Training Complex (EGTTR/ETTC)
- White Sands Missile Range
- Utah Test and Training Range
- Point Mugu, Naval Air Station
- Naval Air Warfare Center – Aircraft Division, Patuxent River

Figure 2.3-1. Proposed Munition Impact Area



These ranges provide both water and land areas for weapons employment. The availability of a water range was not a deciding factor when determining the suitability of these locations. Rather, the decision was focused on a range's ability to (1) support the large airspace requirements for long range strike weapons, (2) instrument the range for flight termination system capabilities as well as telemetry support and relays for full-scale maneuvers, (3) score weapon impacts and performance, and (4) provide adequate operational flexibility and support to accommodate Long Range Strike WSEP missions. A brief description of each range and their limitations in meeting Long Range Strike WSEP objectives is discussed in the following subsections.

2.3.1 Eglin Gulf Test and Training Range/Eglin Test and Training Complex

The EGTTR consists of 102,000 NM^2 of overwater airspace, but it is not instrumented south of the W-151 airspace unit. With the deployment of an instrumentation barge for relay, missions can be conducted out to 15 NM from shore. The land range covers 724 square miles (547 NM^2) with 70 specific test and training areas and is highly instrumented with extensive target capability, such as stationary target complexes and remotely controlled high- and slow-speed moving targets. However, there are multiple limitations in the EGTTR/ETTC that eliminate it as a possibility for conducting Long Range Strike WSEP missions including:

- No flight termination system/telemetry coverage for weapon drops south of W-151 airspace
    - In the past, Eglin has used mobile telemetry systems at places such as Homestead for previous weapons test to ensure coverage of the entire weapon footprint or alternatively using airborne assets for telemetry and flight termination system. Eglin is pursuing the Gulf Range Enhancement Project that will build semi-permanent instrumentation sites down the western coast of Florida to Key West; however, that capability will not exist in time for the Proposed Actions of this EA/OEA.
- Weapon scoring conducted with high-definition video cameras and examination of targets post-mission.
- No GPS jamming for MALD-J evaluations
    - Eglin has conducted jamming over water but has never had a requirement to conduct GPS jamming on land. It is a capability that could potentially be provided.
- Limited weapon profiles based on safety restrictions for land and water ranges, as well as high-volume marine traffic on the water ranges

2.3.2 White Sands Missile Range

The White Sands Missile Range is the largest open-air land missile range in the U.S, consisting of 6,000 square miles (4,531 NM^2) of restricted airspace owned and controlled by the U.S. Army. It is an instrumented range with extensive land target capability, including stationary complexes, remotely controlled moving targets, and electronic warfare assets. It also has extensive GPS jamming capabilities. Limitations preventing Long Range Strike WSEP missions from occurring there are listed below:

- No capability to evaluate JASSMs during mid-course routes
- Safety restrictions do not allow for long range SDBs
- No maximum range for JASSM, SDB, and MALD

2.3.3 Utah Test and Training Range (UTTR)

The Utah Test and Training Range (UTTR) is the largest contiguous block of supersonic restricted airspace in the continental U.S., consisting of 2,634 square miles (1,989 NM^2). The range is highly instrumented with telemetry reception and recording of various weapon systems and GPS jamming capabilities. It also provides a large array of targets developed from previous WSEP missions. However, UTTR's limitations preventing Long Range Strike WSEP missions from being conducted include:

- No capability to evaluate JASSM during mid-course routes
- Safety restrictions that do not allow for long range SDB
- No maximum range for JASSM, SDB, and MALD

2.3.4 Point Mugu, Naval Air Station

Point Mugu has 27,000 NM^2 of over-water range area with the potential to expand to approximately 166,000 NM^2. Portions of the airspace are highly instrumented, using islands and E-3Cs for overlapping instrumentation coverage. The range supports weapons, ships, aircraft, and specialized systems testing and is capable of dense electronic combat environments. The range also provides aerial, seaborne, and littoral targets. Limitations preventing Long Range Strike WSEP missions from being conducted at Point Mugu are listed below:

- Limited size of instrumented airspace
- Limited weapon scoring capabilities

2.3.5 Naval Air Warfare Center - Aircraft Division (NAWC-AD), Patuxent River

The Naval Air Warfare Center - Aircraft Division (NAWC-AD) contains 5,000 square miles (3,776 NM^2) of controlled airspace and 780 square miles (589 NM^2) of restricted airspace. It is the Navy's principal research development test and evaluation site for naval aircraft, engines, avionics, and support systems, including fixed- and rotary-wing aircraft. It also provides a varied climate test environment. NAWC-AD was eliminated as a possible location for Long Range Strike WSEP missions based on the following limitations:

- No GPS jamming capability for MALD-J evaluations
- No targets or weapon scoring capability
- Airspace not instrumented for weapons tracking

2.3.6 Summary of Alternate Locations and Limitations Measured Against Screening Criteria

Table 2.3-1 compares ranges that were identified and described above with the screening criteria described in Section 2.2 for meeting the purpose and need of the Proposed Action.

Table 2.3-1. Comparison of Ranges with Screening Criteria

Location	Airspace Requirements	Fully Instrumented Range	Weapon Impact Scoring	Range Flexibility
EGTTR/ETTC	No	No	Yes	No
White Sands Missile Range	No	Yes	No	No
UTTR	No	Yes	Yes	No
Point Mugu, NAS	Yes	No	No	No
NAWC-AD, Patuxent River	No	No	No	No
PMRF, Kauai	Yes	Yes	Yes	Yes

EGTTR/ETTC = Eglin Gulf Test and Training Range/Eglin Test and Training Complex; UTTR = Utah Test and Training Range; NAS = Naval Air Station; NAWC-AD = Naval Air Warfare Center - Aircraft Division; PMRF = Pacific Missile Range Facility

Based on selection standards described in Section 2.2, the BSURE portion of PMRF was the only range area that could provide large enough airspace with proper instrumentation to track and score weapon performance and meet other operational requirements, including the ability to contain and clear a large weapon safety footprint for full-scale maneuvers of long range strike weapons. Therefore, the action alternatives previously described in Section 2.2 focus solely on the level of munitions used during Long Range Strike WSEP activities that would be conducted at PMRF.

2.4 Impact Summary

Potential impacts under each alternative are summarized in Table 2.4-1.

Table 2.4-1. Summary of Potential Impacts for All Alternatives

Resource	Alternative 1 (Preferred Alternative)	Alternative 2	No Action Alternative
Air Quality	Based on air emissions modeling and analysis, Long Range Strike WSEP activities would not be expected to result in any significant increase in air emissions. The distance from shore where most activities would occur further reduces the possibility for adverse impacts to onshore air quality such that there would be no significant impacts.	Under Alternative 2, the potential air quality impacts would be the same as those under Alternative 1.	Long Range Strike WSEP missions would not be conducted; therefore, no impacts to air quality would occur.
Noise Impacts to the Public	In-air noise from detonations of the largest proposed long range strike weapon (based on net explosive weight) were calculated and compared against criteria and thresholds for pain and moderate annoyance to the public. Potentially annoying levels of noise would be experienced over 10 NM from the detonation point. Given that the weapon impact point would be 44 NM from the shore of Kauai, noise levels resulting in pain and annoyance would not reach populated areas on land. Moreover, clearing the safety hazard area would prevent the public from being exposed to noise levels that could result in pain. Alternative 1 would have no impacts to the public from noise.	The potential noise impacts to the public under Alternative 2 would be the same as those under Alternative 1.	There would be no noise impacts to the public since Long Range Strike WSEP activities would not occur.
Airspace	The planned mission level of no more than five mission days annually is not considered a significant increase that would impact airspace availability. The proponent would coordinate with the appropriate scheduling agency to request airspace units needed for various portions of the mission and would follow the appropriate steps in scheduling the airspace. There would be no significant impacts to airspace utilization and capacity under Alternative 1.	Under Alternative 2, the potential impacts to airspace would be the same as those under Alternative 1.	Long Range Strike WSEP missions would not be conducted at PMRF and there would be no impacts to airspace utilization and capacity.
Public Safety	Nonparticipating vessels and persons would be kept from the mission area by use of aircraft and Notice to Mariners. Closure of the mission area would be temporary and intermittent. Continuous surveillance of the safety hazard area would ensure a clear range before any mission activities commence. Overall, there would be no significant impacts from Alternative 1 with regard to public safety.	Under Alternative 2, the potential impacts to public safety would be the same as those under Alternative 1.	There would be no significant impacts to public safety since Long Range Strike WSEP activities would not occur.

Table 2.4-1. Summary of Potential Impacts for All Alternatives (Cont'd)

Resource	Alternative 1 (Preferred Alternative)	Alternative 2	No Action Alternative
Socioeconomics	No significant impacts to socioeconomic resources would be anticipated under the Proposed Action. The proximity of tourist activities near shore provides less incentive for recreational boaters and fishermen to travel to distances within W-188A. In addition, the emphasis of subsistence fishing in Hawaii is on using traditional methods of catching species, which would not be expected to occur at distances from shore within W-188A. Additionally, no disproportionate impacts to low-income communities, minorities, or children have been identified under the Proposed Action.	Under Alternative 2, the potential socioeconomic impacts would be the same as those under Alternative 1.	There would be no potential impacts to socioeconomic and environmental justice resources from additional access restrictions under this alternative
Cultural Resources	No cultural resources would be affected by activities proposed under Alternative 1. No deep sea shipwrecks or cultural features have been identified within the APE for the Long Range Strike WSEP missions. In addition to resources not being located within the APE, munitions utilized under Alternative 1 would detonate at the surface or 3 meters (10 feet) below the water surface. In the case of underwater detonations, overpressure generated by these munitions will not impact cultural resources on the seafloor due to a seafloor depth of 4,645 meters (15,240 feet) The Air Force presented a finding of No Effect on Historic Properties to the Hawaii SHPO.	No cultural resources would be affected by activities proposed under Alternative 2. No deep sea shipwrecks or cultural features have been identified within the APE. Munitions deployed under Alternative 2 would be limited to airbursts and surface detonations. No impacts to cultural resources are anticipated.	Long Range Strike WSEP activities would not be conducted, therefore no impacts to cultural resources would occur.
Physical Resources	There would be no significant impacts to physical resources. Impacts to water column and substrate quality would be minor. Detonations would not be of sufficient strength to cause seafloor cratering.	Under Alternative 2, the potential physical resources impacts would be the same those under Alternative 1.	There would be no significant impacts to physical resources, as Long Range Strike WSEP missions would not occur.
Biological Resources	Marine fish may be injured or killed by detonations, but the number is expected to be negligible relative to overall populations. Subsurface detonations would not significantly affect benthic communities. Known hardbottom habitats and artificial reefs would be avoided. Essential fish habitat would not be significantly impacted. No impacts to marine birds, including ESA-listed and migratory species, are expected. Marine mammals and sea turtles could be exposed to noise or pressure levels resulting in mortality, injury, or harassment. The 86 FWS completed consultations under the ESA and MMPA for 2016 missions. NMFS issued a	Surface detonations would potentially result in lower numbers of mortality, injury, and harassment of protected species including marine mammals and sea turtles compared to subsurface detonations. The risk of fish kills would be lower. Mitigation measures would decrease the potential for impacts.	There would be no significant impacts to biological resources, as Long Range Strike WSEP activities would not occur.

Table 2.4-1. Summary of Potential Impacts for All Alternatives (Cont'd)

Resource	Alternative 1 (Preferred Alternative)	Alternative 2	No Action Alternative
	Biological Opinion/Incidental Take Statement on September 29, 2016, and an IHA on September 27, 2016. A Programmatic Biological Opinion/Incidental Take Statement under the ESA and a Letter of Authorization under the MMPA for 2017–2021 missions will be issued by NMFS before the 86 FWS commences mission activities in 2017.		

86 FWS = 86th Fighter Weapons Squadron; APE = Area of Potential Effects; ESA = Endangered Species Act; LOA = letter of agreement; MMPA = Marine Mammal Protection Act; NM = nautical miles; NMFS = National Marine Fisheries Service; PMRF = Pacific Missile Range Facility; SHPO = State Historic Preservation Officer

This page is intentionally blank.

3.0 AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

3.1 Air Quality

3.1.1 Definition of the Resource

Air pollution can threaten public health and damage the environment. Congress passed the Clean Air Act and its amendments, which set regulatory limits on air pollutant emissions and help to ensure basic public health and environmental protection from air pollution. Air pollution damages trees, crops, other plants, lakes, and animals. In addition to damaging the natural environment, air pollution damages the exteriors of buildings, monuments, and statues. It can create haze or smog that reduces visibility in national parks and cities or that interferes with aviation.

Air quality is defined by atmospheric concentrations of specific air pollutants—pollutants the USEPA determined may affect the health or welfare of the public. The six major air pollutants of concern, called "criteria pollutants," are carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), ozone (O_3), suspended particulate matter (PM), and lead (Pb). Suspended particulate matter is further categorized as particulates less than or equal to 10 microns in diameter (PM_{10}) and fine particulate matter less than or equal to 2.5 microns in diameter ($PM_{2.5}$). The USEPA established NAAQS for these criteria pollutants.

In addition to the six criteria pollutants, the USEPA designated 188 substances as hazardous air pollutants under the federal Clean Air Act. Hazardous air pollutants are air pollutants known to cause or suspected of causing cancer or other serious health effects or adverse environmental effects (USEPA, 2015a). The State of Hawaii recognizes only the 188 federally designated hazardous air pollutants.

NAAQS have not been established for hazardous air pollutants. However, the USEPA has developed rules that limit emissions of hazardous air pollutants from specific industrial sources. These emissions control standards are known as "maximum achievable control technologies" and "generally achievable control technologies." They are intended to achieve the maximum degree of reduction in emissions of hazardous air pollutants, taking into consideration the cost of emissions control, non-air quality health and environmental impacts, and energy requirements.

Examples of hazardous air pollutants include benzene, which is found in gasoline; perchloroethylene, which is emitted by some dry cleaning facilities; and methylene chloride, a solvent and paint stripper used in some industries. Hazardous air pollutants are regulated under the Clean Air Act's National Emission Standards for Hazardous Air Pollutants, which apply to specific sources of hazardous air pollutants, and under the Urban Air Toxics Strategy, which applies to area sources.

Ozone, a major component of photochemical smog, is a secondary air pollutant, which means it is not emitted directly but formed when precursor chemicals react with light, water, and/or other environmental factors to produce the pollutant. Ozone precursors consist of two groups of chemicals: nitrogen oxides (NO_X) and organic compounds. Nitrogen oxides consist of nitric oxide (NO) and nitrogen dioxide. Organic compound precursors of ozone are routinely described by various terms, including volatile organic compounds, reactive organic compounds, and reactive organic gases.

Air pollutant emissions are reported as the rate (by weight or volume) at which specific compounds are emitted into the atmosphere by a source. Typical units for emission rates from a source are pounds per thousand gallons of fuel burned, pounds per U.S. ton of material processed, and grams per vehicle-mile traveled.

Ambient air quality is reported as the atmospheric concentrations of specific air pollutants at a particular time and location. The units of measure are expressed as a mass per unit volume (e.g., micrograms per cubic meter of air) or as a volume fraction (e.g., parts per million by volume).The ambient air pollutant concentrations measured at a particular location are determined by the pollutant emissions rate, local meteorology, and atmospheric chemistry. Wind speed and direction, the vertical temperature gradient of the atmosphere, and precipitation patterns affect the dispersal, dilution, and removal of air pollutant emissions from the atmosphere.

Climate Change

Greenhouse gases (GHGs) are compounds that contribute to the greenhouse effect—a natural phenomenon in which gases trap heat in the lowest layer of the earth's atmosphere (surface-troposphere system), causing heating (radiative forcing) at the surface of the earth. The primary long-lived greenhouse gases directly emitted by human activities are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride (SF_6). Carbon dioxide, methane, and nitrous oxide occur naturally in the atmosphere. However, their concentrations have increased from the preindustrial era (1750) to 2008: carbon dioxide (38 percent), methane (149 percent), and nitrous oxide (23 percent) (USEPA, 2009a).

These gases influence global climate by trapping heat in the atmosphere that would otherwise escape to space. The heating effect of these gases is considered the probable cause of the global warming observed over the last 50 years (USEPA, 2009a). Climate change can affect many aspects of the environment. Not all impacts of greenhouse gases are related to climate. For example, elevated concentrations of carbon dioxide can lead to ocean acidification and stimulate terrestrial plant growth, and methane emissions can contribute to higher ozone levels. The administrator of the USEPA determined that six greenhouse gases taken in combination endanger both the public health and the public welfare of current and future generations. The USEPA specifically identified carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride as greenhouse gases (USEPA, 2009b; 74 *Federal Register* 66496, December 15, 2009).

To estimate the global warming potential (GWP), the United States quantifies greenhouse gas emissions using the 100-year time frame values established in the Intergovernmental Panel on Climate Change Second Assessment Report (Intergovernmental Panel on Climate Change, 1995), in accordance with United Nations Framework Convention on Climate Change reporting procedures (United Nations Framework Convention on Climate Change, 2004). All GWPs are expressed relative to a reference gas, carbon dioxide, which is assigned a GWP equal to 1. The five other greenhouse gases have a greater GWP than carbon dioxide, ranging from 21 for methane, 310 for nitrous oxide, 140 to 6,300 for hydrofluorocarbons, 6,500 to 9,200 for perfluorocarbons, and up to 23,900 for sulfur hexafluoride. To estimate the carbon dioxide equivalency of a non-carbon dioxide greenhouse gas, the appropriate GWP of that gas is multiplied by the amount of the gas emitted. All six greenhouse gases are multiplied by their GWP and the results are added to calculate the total equivalent emissions of carbon dioxide (CO_2e). The dominant greenhouse gas emitted is carbon dioxide, mostly from fossil fuel combustion (85.4 percent) (USEPA, 2009c). Weighted by GWP, methane is the second largest component of emissions, followed by nitrous oxide. Global warming potential-weighted emissions are presented in terms of equivalent emissions of carbon dioxide, using units of teragrams (1 million metric tons or 1 billion kilograms [teragrams (Tg)]) of CO_2e (Tg CO_2e). The Proposed Action is anticipated to release greenhouse gases to the atmosphere. These emissions are quantified for Long Range Strike WSEP missions in the BSURE Area, and estimates are presented in Chapter 4.

3.1.2 Affected Environment

NAAQS for criteria pollutants are set forth by the USEPA under the authority of the Clean Air Act in order to establish pollutant concentration thresholds to protect public health and welfare. Areas that exceed a standard are designated as "nonattainment" for that pollutant, while areas that are in compliance with a standard are in "attainment" for that pollutant. An area may be classified as nonattainment for some pollutants and attainment for others simultaneously.

The Long Range Strike WSEP mission area is offshore of Hawaii, and some elements of the Proposed Action may occur within or over state waters. The attainment status for most of the study area is unclassified, because only areas within state boundaries are classified. The federal Clean Air Act has no provision for classifying waters outside of the boundaries of state waters. Because of the prevailing onshore winds during certain seasons and at certain times of day, offshore emissions of air pollutants from Proposed Action activities may be transported to and affect air quality in adjacent onshore areas.

The NAAQS attainment status of adjacent onshore areas is considered in determining whether appropriate controls on air pollution sources in the adjacent offshore state waters are warranted.

Climate

The climate of the Pacific Ocean offshore of the Hawaiian Islands is subtropical. Offshore winds are predominantly from the north, northeast, and east at 10 to 20 miles per hour (5 to 10 meters per second). Air temperatures are moderate and vary slightly by season, ranging from about 70 to 80 degrees Fahrenheit (°F) (21 to 27 degrees Celsius [°C]). Estimated annual rainfall in ocean areas offshore of Hawaii is estimated at about 25 inches (64 centimeters), with most rainfall during the winter (Western Regional Climate Center, 2010).

The climate of Hawaii influences air quality in several ways. The prevailing trade winds provide strong, regular regional ventilation that quickly disperses air pollutants and breaks up inversion layers. Frequent rainfall on windward sides of the islands washes dust and other air pollutants out of the atmosphere. During mild kona weather (i.e., absence of daily trade winds), local air pollutant concentrations may temporarily increase and volcanic organic gases emissions from the Island of Hawaii may temporarily affect the other islands in the Main Hawaiian Islands.

Baseline Emissions

No major stationary sources of air pollutant emissions exist within the Long Range Strike WSEP mission area. However, air pollutants generated on adjacent land areas may be transported into the mission area, and vice versa.

The largest point sources of air pollutants in the Hawaiian Islands are power-generating stations, petroleum refining, and agriculture. Most stationary air pollutant sources are located on Oahu. Maui County emissions total about one-third of Oahu emissions, Kauai emissions are about one-half of Maui County emissions, and the Island of Hawaii accounts for less than 10 percent of total emissions. Heavy volumes of automobile traffic during commute hours in urban areas may occasionally cause concentrations of primary pollutants to exceed short-term air quality standards. However, the small number of major sources, dispersed population centers, and generally good ventilation from daily trade winds combine to ensure that air quality in Hawaii is good to excellent. Volcanic organic gases from volcanic eruptions on the Island of Hawaii are a major natural source of air pollution in Hawaii. Volcanic organic gases have an especially strong influence on air quality in the Hawaiian Islands during kona weather, when winds are from the south.

Emissions that would be generated were compared with the latest available Hawaii state emissions obtained from USEPA's 2011 National Emissions Inventory (NEI) (last updated December 3, 2015); these are presented in Table 3.1-1. The county data include emissions amounts from point sources, area sources, and mobile sources. *Point sources* are stationary sources that can be identified by name and location. *Area sources* are point sources from which emissions are too low to track individually, such as a home or small office building, or a diffuse stationary source, such as wildfires or agricultural tilling. *Mobile sources* are any kind of vehicle or equipment with gasoline or diesel engine, an airplane, or a ship. Two types of mobile sources are considered: on-road and nonroad. On-road sources consist of vehicles such as cars, light trucks, heavy trucks, buses, engines, and motorcycles. Nonroad sources are aircraft, locomotives, diesel and gasoline boats and ships, personal watercraft, lawn and garden equipment, agricultural and construction equipment, and recreational vehicles (USEPA, 2015b).

Table 3.1-1. Baseline Criteria Pollutant Emissions Inventory Hawaii

Criteria Pollutant (tons/year)						
	CO	NO_X	PM_{10}	$PM_{2.5}$	SO_2	VOCs
Total	372,062	109,689	51,757	16,753	55,270	80,657

Source: USEPA, 2015b
CO = carbon monoxide; NO_x = nitrogen oxides; PM_{10} and $PM_{2.5}$ = particulate matter with a diameter of less than or equal to 10 microns and 2.5 microns, respectively; SO_2 = sulfur dioxide; VOC = volatile organic compound

GHG Emissions/Baseline

Greenhouse gases are gases that trap heat in the atmosphere; the accumulation of these gases in the atmosphere has been attributed to the regulation of Earth's temperature. The primary long-lived GHGs directly emitted by human activities are CO_2, N_2O, and CH_4. Thus, regulations to inventory and decrease emissions of GHGs have been promulgated. On October 30, 2009, the USEPA published a rule for the mandatory reporting of GHGs from sources that, in general, emit 25,000 metric tons or more of carbon dioxide equivalent per year in the United States. The USEPA also recently promulgated the Prevention of Significant Deterioration and Title V GHG Tailoring Rule, which will impose GHG permitting requirements on existing major sources with major modifications and certain new major sources. At this time, a threshold of significance has not been established for the emissions of GHGs.

The six primary GHGs, defined in Section 19(i) of EO 13514, *Planning for Federal Sustainability in the Next Decade*, Section 19 (m) March 2015, are carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride. Each GHG has an estimated GWP, which is a function of its atmospheric lifetime and its ability to absorb and radiate infrared energy emitted from the Earth's surface. The GWP allows GHGs to be compared with each other by converting the GHG quantity into the common unit "carbon dioxide equivalent."

Revised draft guidance from CEQ, dated December 18, 2014, recommends that agencies consider both the potential effects of a proposed action on climate change, as indicated by its estimated GHG emissions, and the implications of climate change for the environmental effects of a proposed action. The guidance also recommends that agencies consider 25,000 metric tons of CO_2e emissions on an annual basis as a reference point below which a quantitative analysis of GHG is not recommended unless it is easily accomplished based on available tools and data. Baseline GHG emissions for Hawaii, obtained from USEPA's 2011 NEI, are summarized in Table 3.1-2.

Table 3.1-2. Baseline Greenhouse Gas Emissions Inventory for Hawaii

Greenhouse Gases (tons/year)				
County	CO_2	N_2O	CH_4	CO_2e
Total	6,287,096	303	651	12,561,578

Source: USEPA, 2015b
CH_4 = methane; CO_2 = carbon dioxide; CO_2e = carbon dioxide equivalent; N_2O = nitrous oxide

3.1.3 Environmental Consequences

Section 176(c)(1) of the Clean Air Act, commonly known as the General Conformity Rule, requires federal agencies to ensure that their actions conform to applicable implementation plans for achieving and maintaining the NAAQS for criteria pollutants. The entire state of Hawaii is classified as being in attainment for all criteria pollutants.

The analysis of health-based air quality impacts under NEPA includes estimates of criteria air pollutants for all training and testing activities where aircraft, missiles, or targets operate at or below 3,000 feet (914 meters) above ground level or that involve vessels in U.S. territorial seas. The analysis of health-based air quality impacts under EO 12114, which covers emissions outside of the U.S. territorial seas, includes emissions estimates of only those training and testing activities in which aircraft, missiles, or targets operate at or below 3,000 feet (914 meters) above ground level or that involve vessels outside of U.S. territorial seas.

Air pollutants emitted more than 3,000 feet (914 meters) above ground level are considered to be above the atmospheric inversion layer and, therefore, do not affect ground-level air quality (USEPA, 1992). Thus, these emissions do not affect the concentrations of air pollutants in the lower atmosphere, measured at ground-level monitoring stations, upon which federal, state, and local regulatory decisions are based. For the analysis of the impacts on global climate change, however, all emissions of GHGs from aircraft and vessels participating in training and testing activities, as well as targets and ordnance expended, are included regardless of altitude (see Chapter 4).

Criteria air pollutants are generated by the combustion of fuel in surface vessels and fixed-wing and rotary-wing aircraft. They also are generated by the combustion of explosives and propellants in various types of munitions. The nature of the munitions involved is such that those using propellants (e.g., JASSM, HARM) will be doing so at an altitude above the 3,000-foot mixing layer except when making final descent toward the target. As such, the time below 3,000 feet would be merely seconds and, therefore, emissions from propellants are considered to be nominal and were not calculated. Other munitions are free-falling weapons that utilize guidance mechanisms and do not require propellant. For these reasons, only the emissions from surface/above-surface detonations were calculated with respect to ordnance. Emissions were calculated based on maximum end-state ordnance quantities provided in Table 2.2-1.

In order to evaluate air emissions and their impact on the overall ROI, the emissions associated with the project activities were compared with the total emissions on a pollutant-by-pollutant basis for the ROI's 2011 NEI data. Potential impacts to air quality are evaluated with respect to the extent, context, and intensity of the impact in relation to relevant regulations, guidelines, and scientific documentation. The CEQ defines significance in terms of context and intensity in 40 CFR 1508.27. This requires the significance of the action to be analyzed with respect to the setting of the proposed action and based relative to the severity of the impact. The CEQ NEPA regulations (40 CFR 1508.27[b]) provide 10 key factors to consider in determining an impact's intensity.

Aircraft emission factors were derived from the Air Conformity Applicability Model (ACAM) Version 5.0.1 and the Navy's Aircraft Environmental Support Office (AESO) memoranda reports to provide a level of consistency with respect to emissions factors and calculations. Air emissions were calculated by time spent below 3,000 feet at intermediate or cruise power settings for fixed- and rotary-wing aircraft, respectively. The USEPA's AP-42, *Compilation of Air Pollutant Emission Factors, Fifth Edition, Volume I, Chapter 15: Ordnance Detonation*, was used to calculate emissions associated with ordnance detonation. Further details, equations, and emission factors can be found in Appendix B, *Air Quality Emissions Calculations*.

The air quality analysis focused on emissions associated with aircraft emissions occurring below 3,000 feet above ground level (AGL), ordnance detonation, and seagoing vessel outboard motor emissions.

GHGs were included in the analysis. The primary source of carbon dioxide emissions would be fuel combustion from aircraft emissions during training activities. GHG emissions were compared with the CEQ's minimum level of 25,000 metric tons (27,558 tons) as a level at which consideration would be required in NEPA documentation. Air quality calculations are provided in Appendix B.

3.1.3.1 No Action Alternative

The No Action Alternative would not result in any additional impacts to air quality beyond the scope of baseline conditions and influences within the ROI.

3.1.3.2 Alternative 1 (Preferred Alternative)

Emissions associated with the Proposed Action are calculated and summarized in Table 3.1-3. Impacts would amount to 0.03 percent or less of each of the criteria pollutants. GHG emissions would be less than 25,000 metric tons (27,558 tons).

Table 3.1-3. Alternative 1 and 2 Air Emissions Compared with Baseline Emissions for Hawaii

Category	Emissions (tons/year)						
	VOCs	SOx	NOx	CO	PM_{10}	$PM_{2.5}$	CO_2e
Hawaii baseline emissions	**372,062**	**109,689**	**51,757**	**16,753**	**55,270**	**80,657**	**12,561,578**
Aircraft emissions	0.12	0.83	11.88	1.08	1.11	0.87	2,650
Ordnance emissions	0.00	0.05	5.38	2.25	0.00	0.00	0.00
TOTAL emissions	0.07	0.88	17.25	3.36	1.16	0.92	2,633
Percent of ROI emissions	**0.00%**	**0.00%**	**0.03%**	**0.02%**	**0.00%**	**0.00%**	**0.02%**

Source: USEPA, 2015b

CO = carbon monoxide; CO_2e = carbon dioxide equivalent; NO_x = nitrogen oxides; PM_{10} and $PM_{2.5}$ = particulate matter with a diameter of less than or equal to 10 microns and 2.5 microns, respectively; ROI = region of influence; SO_x = sulfur oxides; VOC = volatile organic compound

Based on air emissions modeling and analysis, the Proposed Action would not be expected to result in any significant increase in air emissions. Furthermore, given the distance from shore where most activities associated with the Proposed Action would occur, the variable wind patterns combined with fractional increases in emissions and high potential for pollutant disbursement makes the possibility for adverse impacts to onshore air quality very unlikely. Therefore, there would be no significant impacts to air quality under Alternative 1.

3.1.3.3 Alternative 2

Emissions associated with Alternative 2 would be the same as those for Alternative 1 and are summarized in Table 3.1-3. Impacts would amount to 0.03 percent or less of each of the criteria pollutants. GHG emissions would be less than 25,000 metric tons (27,558 tons). Based on air emissions modeling and analysis, the Proposed Action would not be expected to result in any significant increase in air emissions. Furthermore, given the distance from shore where most activities associated with the Proposed Action would occur, the variable wind patterns combined with fractional increases in emissions and high potential for pollutant disbursement makes the possibility for adverse impacts to onshore air quality very unlikely. Therefore, there would be no significant impacts to air quality under Alternative 2.

3.2 In-Air Noise Impacts to the Public

3.2.1 Definition of the Resource

Noise may be thought of as sound that is annoying or painful. In air, the normal human ear can detect sounds ranging from about 20 hertz (Hz) to about 20,000 Hz. The hertz is a measurement of sound waves or cycles per second, more simply referred to as frequency. The human ear is most sensitive to frequencies in the in the 1,000- to 4,000-Hz range. The loudness of a sound is expressed in terms of decibels. The decibel is a logarithmic unit of relative sound signal strength that closely matches how humans hear sound. Decibels (dB) can be used to define the lower limits of sound humans can detect and the upper limits of sound that humans can tolerate. For example, a 1,000-Hz tone of 0 dB is barely detectible, whereas some 140-dB sounds can cause hearing damage depending on the duration of the sound (United States Army Center for Health Promotion and Preventive Medicine [USACHPPM], 2005).

Because sounds can have many qualities, such as intensity or loudness, frequency, duration, and, from the perspective of the listener, the distance from the sound source, multiple units of measure or metrics have been developed to define and understand sounds (USACHPPM, 2005). The Proposed Action would involve aircraft sound or noise, which is transient in duration, as well as explosive noise, which is brief or impulsive in nature. Transient noise has a beginning and an end, where the sound rises in loudness above the background and then subsides again, as with a passing jet. Impulse noise is intense and of short duration, usually lasting less than a second, as with a sonic boom or bomb detonation (USACHPPM, 2005).

Transient noise can be expressed in terms of sound exposure level (SEL), which is derived by adding the total acoustic energy in a transient event and normalizing it to a one-second duration, thus allowing comparison of the relative annoyance of different transient sounds. Multiple transient sounds or continuous steady noise sources can be expressed as a time average, termed day-night level (DNL). Typical DNLs used are 8-hour, 24-hour, and annual. Impulse noise is expressed in peak sound pressure level (measured in decibels as dBP or unweighted) and SEL C-weighted decibels (USACHPPM, 2005). Weighting of the decibel scale emphasizes certain frequencies of a type of sound for the purpose of tailoring the noise to human hearing. C-weighting is applied to impulsive noise to better consider the vibrations caused by the lower frequencies of a sonic boom or explosion that may be annoying to people. It is also used in determining an average noise exposure over time (i.e., daily, monthly) from multiple noise events. A-weighting of SELs is applied to transient and continuous sources of noise and averaged over time to set allowable workplace exposure standards. Typical unweighted (dBP) sound pressure levels and A-weighted everyday noise sources are listed in Table 3.2-1 and Table 3.2-2.

Table 3.2-1. Some Typical Values of Peak SPL for Impulse Noise

Sound Pressure Level (dBP)	Example
190+	Within blast zone of exploding bomb
160–180	Within crew area of heavy artillery piece or naval gun when shooting
140–170	At shooter's ear when firing hand gun
125–160	At child's ear when detonating toy cap gun or firecracker
120–140	Metal-to-metal impacts in many industrial processes (e.g., drop-forging, metal beating)
110–130	On construction site during pile driving

Source: USEPA, 1974
dBP = decibels, peak sound pressure level

Table 3.2-2. Typical A-Weighted Levels of Common Sounds

Noise Level (dBA)	Example
20	Rustling leaves
34	Whisper
55	Window air conditioner
60	Conversation
92	Diesel truck (at 25 feet)
98	Lawn mower
115	Chain saw

Source: U.S. Army, 1975
dBA = decibels, A-weighted

Impacts to the public from explosive sound may be categorized as either injurious or noninjurious (annoyance). Federal health and safety standards prescribe that a person should never be exposed to impulsive sounds greater than 140 dBP without ear protection (29 CFR Chapter XVII Section 1926.52[e]). For the purposes of analysis, the proposed threshold for annoyance to humans is 115 dBP for munitions, artillery, and high explosives (USACHPPM, 2005; DoD Noise Working Group, 2013). Noise levels below 115 dBP for single ordnance events are considered insignificant and do not require mitigations (USACHPPM, 2005). In summary, the criteria for impact analysis for this environmental assessment are as follows:

- 140 dBP: Threshold of pain. Exposure to the public of this level would constitute a significant impact.
- 115 dBP to 130 dBP: Moderate annoyance to the public. Exposure to the public of this level would not result in significant annoyance to the public but could require public coordination.

3.2.2 Affected Environment

For the purposes of analysis, the affected public noise environment is considered to be the water and airspace of BSURE. Existing sources of noise at BSURE include often continuous sources, such as wind and surf, and transient or temporary sources, such as thunder, maritime transportation, recreational and commercial vessels, and commercial and military aircraft, and munitions noise.

Military activities involving aircraft generally are dispersed over large expanses of open ocean but can be highly concentrated in time and location. Fixed- and rotary-wing aircraft are used for a variety of training and testing activities throughout the Study Area, contributing both airborne and underwater sound to the ocean environment. Aircraft used in training and testing generally have reciprocating, turboprop, or jet engines. Motors, propellers, and rotors produce the most noise, with some noise contributed by aerodynamic turbulence. Aircraft sounds have more energy at lower frequencies. In the vicinity of these military activities, noise may be significant but falls off rapidly as one moves away from the source. Additionally, because the activities take place several nautical miles out to sea, few or no human receptors are exposed to the noise (DoN, 2010).

3.2.3 Environmental Consequences

3.2.3.1 No Action

Under the No Action Alternative, the Proposed Action would not occur. Long Range Strike WSEP missions would not be conducted and no live or inert releases of munitions related to Long Range Strike WSEP would occur at PMRF. There would be no increase in noise impacts. However, the No Action Alternative would not meet the purpose and need for the Proposed Action.

3.2.3.2 Alternative 1 (Preferred Alternative)

Major sources of noise from the Proposed Action would be from detonations or explosions of different types of ordnance just above, on, and just below the sea surface within the BSURE range. Underwater detonations, addressed in Section 3.8 for their potential to affect marine species, would also produce in-air noise, but much of the explosive energy would be contained in the water. Thus, the in-air detonations would produce the loudest sound during the WSEP event. Comparatively, minor noise sources include aircraft and long-range munitions operating at altitudes above 3,000 feet. Table 3.2-3 lists noise levels from proposed aircraft at several altitudes. Noise levels of aircraft from WSEP missions could be heard by anyone in the local vicinity but would not adversely affect people on the island of Kauai, given that the aircraft would be several nautical miles out to sea. Noise from the Proposed Action would not likely extend to other islands in the Hawaiian archipelago.

Table 3.2-3. Estimated A-Weighted Sound Exposure Levels of Proposed Aircraft (dBA)

Aircraft Type	SEL Altitude (feet AGL)				
	200	500	1,000	5,000	10,000
F-15[1]	123	116	111	96	85
F-16[1]	120	113	108	92	84
B-1B[2,3]	124	112	107	92	82
F-22[3]	-	114	108	89	77
KC-135A[3,4]	118	95	90	75	67
P-3[2]	97	-	-	-	-
F-35[5]	-	115	108	88	78

dBA = decibels, A-weighted; [1]DoN, 2015a; [2]U.S. Air Force, 2007[3]U.S. Air Force, 2010; [4]U.S. Air Force, 2014; [5]Maximum single event noise level as presented in U.S. Air Force, 2016, typically 5-10 dB below SEL values.

The impact point for WSEP missions would be approximately 44 NM north of the island of Kauai within the BSURE range. The detonation at the impact point either on the sea surface or a target object would rapidly release large amounts of energy. This almost-instantaneous release of energy would create extremely high temperatures and pressures that would expand rapidly from the point of detonation, creating a pressure wave and sound. The expanding movement of the pressure wave or blast front would be accompanied by very high winds. The forces of heat, pressure, and noise produced from explosions can kill or injure people or wildlife that are nearby and damage structures. In the immediate vicinity of the explosion, overpressures can exceed 200 pounds per square inch (psi), which is more than 13 times normal atmospheric pressure. Similarly, winds may reach hundreds of miles per hour. Some types of ordnance forcefully expel metal fragments to further damage targets. With distance these forces decrease, subsiding in intensity to levels that would not adversely affect people, wildlife, or structures. At some distance away from the target, noise subsides to a level that may be heard but not pose a concern to people or wildlife. For the Proposed Action, weapons safety hazard areas would be established, surrounding the mission activity. These areas are designed to contain all of the hazards of a particular ordnance but also to encompass the flight characteristics of the munitions being evaluated. Levels of nonharmful noise could extend beyond the weapons safety hazard area.

As discussed in Section 3.2.1, appropriate criteria for explosive noise impacts to the public are 140 dBP and 115 dBP. The 140-dBP level can be calculated using an equation based on TNT equivalent NEW. The equation below gives the distance in feet from the point of detonation of the largest munition, the JASSM, that noise up to 140 dBP would travel. The JASSM contains 300 pounds of TNT-equivalent net explosive. The equation is:

$140 \text{ dBP} = (600) \times \sqrt[3]{\text{NEW}}$,

which is stated as 600 times the cube root of the TNT-equivalent amount of NEW.

For the JASSM, the calculation is 140 dBP = (600) × $^3\sqrt{300}$ = 4,017 feet.

Thus, noise at 140 dBP from an in-air detonation at the sea surface at BSURE would extend out to 4,017 feet from the point of detonation. As noise generally decreases by 6 dB with a doubling of distance, the 115-dBP noise level can be extrapolated from the 140-dBP noise using the distance-decrease relationship (Table 3.2-4). Table 3.2-4 indicates that potentially annoying levels of noise (115 dBP) would be experienced over 10 NM from the detonation point. As the impact point would be 44 NM out to sea, noise levels of 140 dBP or 115 dBP would not reach populated areas on land. Additionally, the safety hazard area, established for the protection of the public, including those participating in maritime transportation and commercial and recreational fishing, would prevent exposure to the public of noise levels at 140 dBP. The Air Force would employ aircraft and vessel visual surveillance and radar to ensure the safety hazard area is clear of members of the public. Thus, Alternative 1 would have no impacts to the public from noise.

Table 3.2-4. Calculated In-Air Noise Levels at Distance from a 300-Pound Detonation

Decibels (dBP)	Distance (Feet)	Distance (NM)
140	4,017	0.7
134	8,033	1.3
128	16,066	2.6
122	32,133	5.3
116	64,266	10.4
110	128,531	21.1
104	257,062	42.3

dBP = decibels, NM = nautical miles; peak sound pressure level

3.2.3.3 Alternative 2

Under Alternative 2, the number of in-air detonations would increase, but the noise intensity and range of in-air noise impact of individual detonations would not increase above that stated in Section 3.2.3.1, Alternative 1 (Preferred Alternative). As with Alternative 1, significant noise levels would not reach populated areas.

3.3 Airspace

3.3.1 Definition of the Resource

The at-sea portion of the HRC geographically encompasses ocean areas located around the major islands of the Hawaiian Islands chain. The offshore areas form an area approximately 1,700 NM by 1,600 NM. The component areas of the HRC include the Hawaii Operating Area (OPAREA), which consists of 235,000 NM^2 of surface and subsurface ocean areas and special use airspace as well as various Navy land ranges and other Services' land used for military training and test activities. Airspace units within the HRC consist of restricted areas, warning areas, and air traffic control assigned airspace. Restricted airspace is an area of airspace over land typically used by the military in which the local controlling authorities have determined that air traffic must be restricted for safety or security concerns. Warning areas are located over water areas and act much like restricted airspace. Air traffic control assigned airspace is assigned by Air Traffic Control, for the purpose of providing air traffic segregation between the specified activities being conducted within the assigned airspace and other instrument flight rules air traffic. This airspace, if not required for other purposes, may be made available for military use. The HRC's electronic tracking ranges at the PMRF, as well as warning areas and special use airspace, enable training to proceed in a safe and structured manner while retaining the flexibility needed to achieve training diversity and operational realism. The PMRF also provides the Navy and DoD an unparalleled ability to engage in the training and testing of missile systems that involve the use or operation of military facilities in California, Alaska, and the western Pacific.

3.3.2 Affected Environment

The HRC geographically encompasses ocean areas located around the Hawaiian Islands chain. The ocean areas extend from 16 degrees north latitude to 43 degrees north latitude and from 150 degrees west longitude to the International Date Line. The largest component of the HRC is the Temporary OPAREA, extending north and west from the island of Kauai, and comprising over 2 million NM^2 of air and sea space. This area is used for Navy ship transits throughout the year and is used only a few times each year for missile defense testing activities. In spite of the Temporary OPAREA's size, nearly all of the training and testing activities in the HRC take place within the smaller Hawaii OPAREA, that portion of the range complex immediately surrounding the island chain from Hawaii to Kauai (Figure 1.2-2).

Special Use Airspace

The HRC includes over 115,000 NM^2 of special use airspace (DoD, 2015). As depicted in Figure 3.3-1, this airspace is almost entirely over the ocean and, as stated above, includes warning areas, air traffic control assigned airspace, and restricted areas.

- Warning Areas of the HRC make up more than 58,000 NM^2 of special use airspace and include the following: W-186, W-187, W-188, W-189, W-190, W-191, W-192, W-193, W-194, and W-196.
- The air traffic control assigned airspace areas of the HRC account for more than 57,000 NM^2 of special use airspace and include the following areas: Luna East, Luna Central, Luna West, Mahi, Haka, Mela South, Mela Central, Mela North, Nalu, Taro, Kaela East, Kaela West, Pele, and Pele South.
- The restricted area airspace over or near land areas within the HRC make up another 81 NM^2 of special use airspace and include R-3101, R-3103, and R-3107. Kaula Island is located completely within R-3107, west-southwest of Kauai.

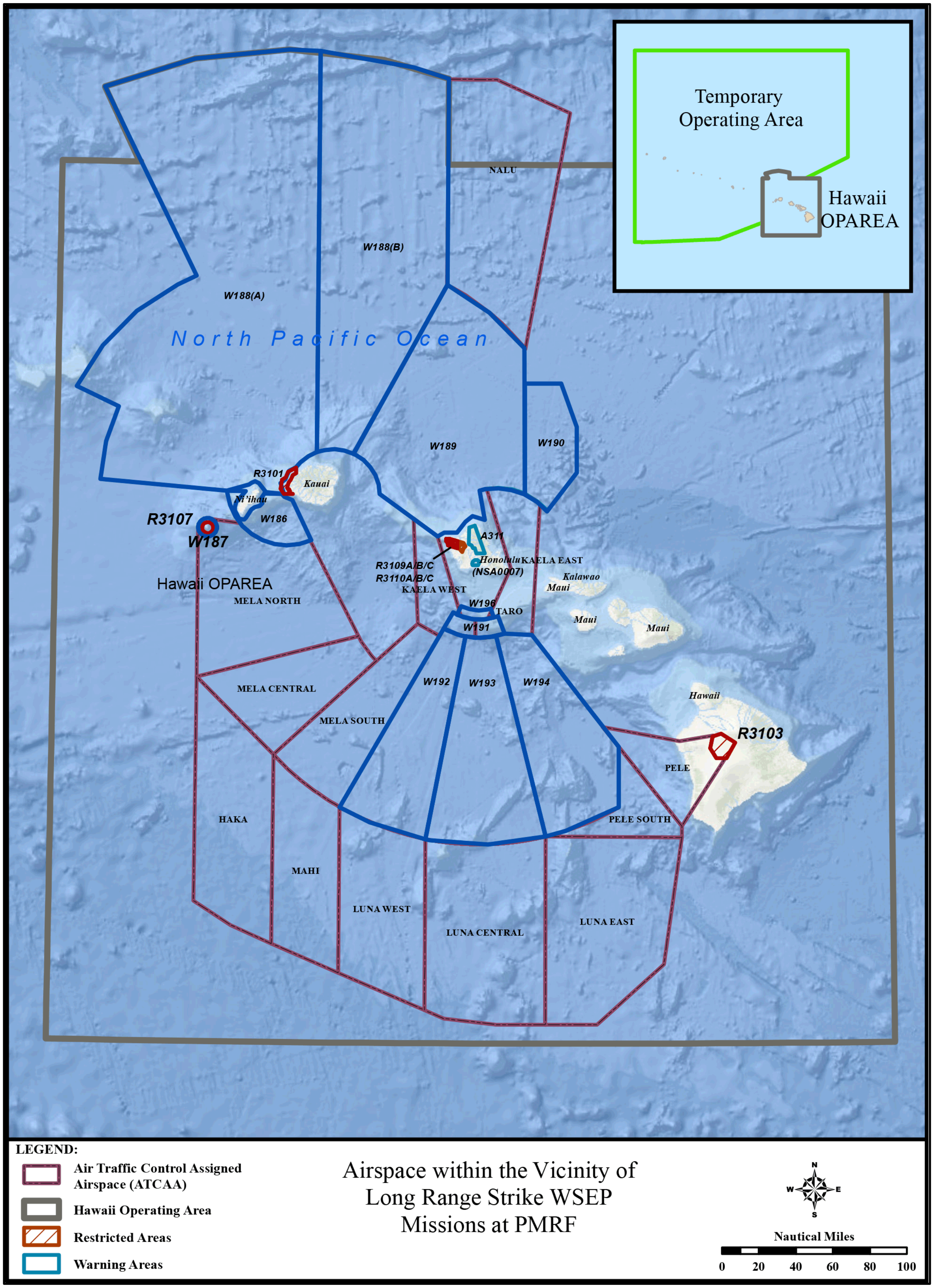
3.3.3 Environmental Consequences

As stated in Section 1.2, W-188A is the primary proposed special use airspace for the long range strike WSEP missions, specifically for most aircraft operations and weapons releases. W-188B may be used for air-to-air refueling operations. Both W-188A and W-188B have different using/scheduling agencies (Glickman, 2015). The using/scheduling agency for W-188A is Commanding Officer, PMRF. The using/scheduling agency for W-188B is Officer in Charge, Fleet Area Control and Surveillance Facility (FACSFAC) Pearl Harbor. If a requesting agency wants to use both W-188A and W-188B simultaneously, they only need to contact the PMRF to schedule. The PMRF and FACSFAC Pearl Harbor have an agreement between each organization regarding how the PMRF will request W-188B (also known as RAINBOW) from FACSFAC. This is a standard procedure in place specifically when the PMRF will require the use of both W-188A and W-188B. If a requestor is only going to use W-188B, then they would only coordinate with FACSFAC. If the requestor is going to use both or W-188A only, then they contact PMRF. In either case, for either action alternative, the proponent would follow the appropriate steps in scheduling the airspace.

3.3.3.1 No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur. Long Range Strike WSEP missions would not be conducted, and additional scheduling of airspace for aircraft operations would not occur. There would be no increase in usage of airspace over existing activities in W-188A and W-188B. However, the No Action Alternative would not meet the purpose and need for the Proposed Action.

Figure 3.3-1. Hawaii Range Complex Airspace



3.3.3.1 Alternative 1 (Preferred Alternative)

The proposed number of aircraft operations within W-188A/B under Alternative 1 would include range clearing activities for human safety and protected species surveys, releasing weapons from mission aircraft, aerial refueling from support aircraft, and relaying of telemetry and flight termination systems. Range clearance activities would be conducted from multiple platforms, including aerial, vessel, and land-based radars. Combined, range clearance activities would be conducted for up to four hours for each mission. The planned mission level of no more than 2 missions per day over a five-day mission set (maximum of 10 missions annually) is not considered a significant increase that would impact airspace availability. Weapon release parameters would be briefed, reviewed, and approved by Range Safety prior to any employment. The majority of the air operations will be operating at higher altitudes with only a minimum of air operations below 3,000 feet and only for a short duration (15 minutes or less).

Unlike restricted areas, warning areas are not required to report annual activity; however, discussions with Range Sustainment Coordinators indicate the relatively small number of operations on an annual basis is not anticipated to stress the airspace/range capacity (Burger and Ashby, 2015). Therefore, Alternative 1 would have no significant impacts to airspace utilization and capacity.

3.3.3.2 Alternative 2

The number of aircraft operations and associated use of W-188A/B under Alternative 2 is the same as what is proposed under Alternative 1. Therefore, under Alternative 2, no significant impacts to airspace utilization and capacity would occur.

3.4 Public Safety

3.4.1 Definition of the Resource

Public safety as discussed in this section refers to aspects of the Proposed Action that are hazardous due to the potential for interaction between mission areas and areas used by the public. Safety analysis includes evaluating risks to public health due to direct strikes by munitions, blast effects and UXO. For actions with inherent safety risks, such as long range strike WSEP missions, the military implements measures to control the risk to the public. Such measures include changing the access status of certain areas to “restricted.” Restricted access means the mission area is temporarily closed to recreational and commercial vessels.

3.4.2 Affected Environment

The affected environment consists primarily of W-188A airspace and underlying surface waters of the Pacific Ocean, particularly waters within a weapon hazard region, or safety hazard area, specific to the munitions involved in the Proposed Action. The center of the safety hazard area would be approximately 44 NM offshore. The exact dimensions of the footprint have not been calculated to date, but the boundary would not be closer than 10 NM from Kauai. The mission hazards for the Proposed Action are similar in nature to ongoing and historical actions at PMRF that involved the testing or expenditure of missiles and other projectiles, impacting targets, and other hazardous activities (DoN, 2010).

For many years, PMRF Range Safety officials have managed operational safety without incident. Federal regulations (33 CFR 165.23 [Regulated Navigation Area and Limited Access Areas] and Subpart C – Safety Zones and 33 CFR 72 [Aids to Navigation]) establish the navigational restrictions for PMRF and authorize the U.S. Coast Guard to implement them for the safety of the public. Nautical charts issued by the NOAA include these federally designated zones and areas.

PMRF standard procedures keep the public safe from inherent hazardous elements of missions by ensuring hazardous areas are clear of nonparticipants. Prior to a hazardous operation, the range is determined to be cleared using inputs from ship sensors, visual surveillance of the range from aircraft and range safety boats, radar data, and acoustic information from a comprehensive system of sensors and surveillance from shore. Advance notification is provided for special operations, including multiparticipant or hazardous weekend firings at PMRF. For such missions, the U.S. Coast Guard and FAA publish dedicated warnings of NOTMARs and NOTAMs, respectively, one week before hazardous operations (DoN, 2010). The local NOTMARs, which are published only over the internet, provide notice to commercial ship operators, commercial fisherman, recreational boaters, and other area users that the military will be operating in a specific area, allowing them to plan their activities accordingly (U.S. Coast Guard, 2013). NOTAMs provide notice to aircraft that the military will be operating in a specific area, allowing aircraft to avoid the corresponding area of airspace until testing activities are complete.

Also, a 24-hour recorded message on the hotline is updated daily by Range Operations to inform the public when and where hazardous operations will take place (DoN, 2010). These temporary clearance procedures for safety purposes have been employed regularly and successfully over time.

3.4.3 Environmental Consequences

3.4.3.1 No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur. Long Range Strike WSEP missions would not be conducted, and no live or inert releases of munitions related to Long Range Strike WSEP would occur at PMRF. There would be no increased potential for impacts with regard to public safety. However, the No Action Alternative would not meet the purpose and need for the Proposed Action.

3.4.3.2 Alternative 1 (Preferred Alternative)

A significant safety impact is defined as one in which the public would be at a high risk for injury or mortality. Potential safety concerns from Long Range Strike WSEP missions include members of the public inadvertently approaching too close to the impact area and risking exposure to blast, noise, and military expended materials. Military expended materials include munition fragments, inert munitions, and ordnance that fails to detonate.

There is a potential for munitions to fail to detonate or dud, resulting in UXO within the mission area. The U.S. Army conducted quality control tests on munitions dud rates and found rates ranged approximately from 3.8 percent for some types of rockets to 8.2 percent for cluster munitions (RAND Corporation, 2005). The dud rates of the various specific munitions for the Proposed Action are expected to be within the range of known rates of other munitions, or roughly 4 to 8 percent (RAND Corporation, 2005). Thus, the Proposed Action would potentially result in a small number of unexploded items remaining on intact target boats or on the seafloor.

Military expended materials from the Proposed Action are dense and mostly metallic and would sink, coming to rest on the seafloor in waters deeper than 6,000 feet. Military expended materials would not pose a public safety hazard, because they would be in waters inaccessible to the public. Once in the marine environment, military expended materials may be subject to a number of processes, including burial, exposure, encasement, and corrosion/degradation. Military expended materials may be buried upon impact with the seafloor (depending on velocity and sediment characteristics) or may become buried over time due to current-induced sediment movement (Wilson et al., 2008).

In observance of existing regulations, an area of ocean surface would be closed to the public each time a live mission is conducted. The size of the closed area would vary depending on the type of weapon being released. The duration of closure of the safety hazard area would be about four hours per day over a maximum of five days of missions annually. Compared with the overall area of accessible Pacific waters in the region, the closed area would be small and established on an intermittent, short-term basis.

Multiple aircraft may be employed to monitor the closed safety hazard area to ensure there is no breach of the safety hazard area by the public. The designated status of W-188A as a "HOT" area, the standard PMRF surveillance and clearing procedures, and the publication of NOTMARs and NOTAMs would serve to inform and protect the public from inherently hazardous elements of the Proposed Action.

Because PMRF has published regulatory procedures for conducting missions and minimizing harm to the public, significant safety impacts are not anticipated. Additionally, military expended materials would come to rest in waters deeper than 6,000 feet and at a point approximately 44 NM from land. Information on Long Range Strike WSEP activities would be made available to the public so individuals can plan accordingly to avoid the area. If a vessel accidentally enters the safety hazard area, PMRF personnel would contact the vessel to request they alter course. Continuous surveillance of the safety hazard area would ensure a "green" or clear range before any mission activities commence. Overall, there would be no significant impacts from Alternative 1 with regard to public safety. Safety measures implemented for Alternative 1 have been in place and effective for several years without incident (DoN, 2010).

3.4.3.3 Alternative 2

Potential public safety considerations would be the same for Alternative 2 as for Alternative 1, as the number of missions would not change and the approach to clearing the hazard safety zone would not change. As with Alternative 1, existing safety measures and range clearance procedures would be observed to ensure the safety of the public.

3.5 Socioeconomics

3.5.1 Definition of the Resource

Socioeconomics refers to features or characteristics of the social and economic environment. Socioeconomic activities associated with the alternatives are concentrated in the BSURE area of the PMRF, which is where long range strike WSEP missions are proposed to take place. The ROI for onshore socioeconomics includes the PMRF, and the ROI for offshore socioeconomics includes the shoreline out to 40 NM off of Kauai. The major socioeconomic concerns are the potential impacts associated with restricted access to the marine environment. Many recreational and commercial activities take place in the waters surrounding Kauai and the BSURE area and are an important economic contributor to the communities on Kauai.

3.5.2 Affected Environment

PMRF

PMRF is located on the western shores of the island of Kauai in the state of Hawaii. The PMRF is an important economic contributor to the local economy. It is one of the largest employers on Kauai, supporting 1,000 jobs and having an estimated $171 million annual economic impact on the local economy (Hanabusa, 2014). PMRF is also an active participant in the community, with contributions to educational, sports, and conservation programs. There are three housing options on PMRF including Family Housing, Unaccompanied Personnel Housing, and Navy Gateway Inns and Suites. Authorized military travelers, DoD civilians, and contractors on official travel orders to PMRF are authorized to stay at Navy Gateway Inns and Suites facilities on a space-available basis (CNIC, 2016a). Off-base lodging at Temporary Lodging Allowance (TLA)-approved hotels is available to accommodate personnel. The most recent estimate for hotel occupancy rate in Kauai was 69.9 percent (State of Hawaii, 2015).

Recreational activities offshore of PMRF/Main Base include surfing, commercial and recreational fishing, and boating. Civilians with a Morale, Welfare and Recreation (MWR) Guest Card are allowed access to Majors Bay, Shenanigans, and beach areas through the PMRF Main gate for 365 days per year (outside of heightened Force Protection Conditions) between the hours of 0500 and 2200 (CNIC, 2016b).

Commercial Transportation and Shipping

Hawaii relies heavily on ocean shipping to supply their everyday needs. It has been estimated that 80 percent of Hawaii's food and merchandise is imported of which 98.6 percent is shipped by sea (HI DOT, 2001). Nawiliwili Harbor and Port Allen Harbor are state-managed commercial harbors located on Kauai. Nawiliwili Harbor, located on the east coast, is the island's major commercial shipping center and cruise ship port (HI DOT, 2016), while Port Allen, located on the southwest coast, serves the military, petroleum suppliers, and tour boat operations (HI DOT, 2001).

Commercial and Recreational Fishing

Commercial fishing throughout Hawaii for all species totaled over 33 million pounds and valued at over $101 million in 2014 (NMFS, 2016a). The majority of commercial fish landings reported in Hawaii during 2012, the most recent data available for landings by distance, was in the high seas (over 200 miles from shore) (NMFS, 2016b). Preliminary data for recreational fishing in Hawaii indicates that the majority of recreational angler trips were ocean trips within 3 miles of the shore (62.4 percent) followed by inland trips (26.8 percent) and ocean trips greater than 3 miles from shore (10.8 percent) (NMFS, 2016c).

A survey by the NOAA Pacific Island Fisheries Science Center was conducted in 2011 for Hawaii Charters to collect information on fees, schedules, and expenditures for Hawaiian Fishing Charters. Based on the survey, Kauai fishing charters each took an average of 66 trips in 12 months, with the majority of trips (39 percent) occurring in July through September followed by January through March (24 percent). Average trips costs and median charter fees by trip type for charter fishing trips are shown in Table 3.5-1. The average trip costs in Kauai were less than the average trip costs for Hawaii's charters overall with Maui having the highest costs and fees. The annual salary for a Captain is estimated at $44,000 with a full day wage (pay by trip) of $150. A full day wage for crew is estimated at $100 (NOAA, 2012).

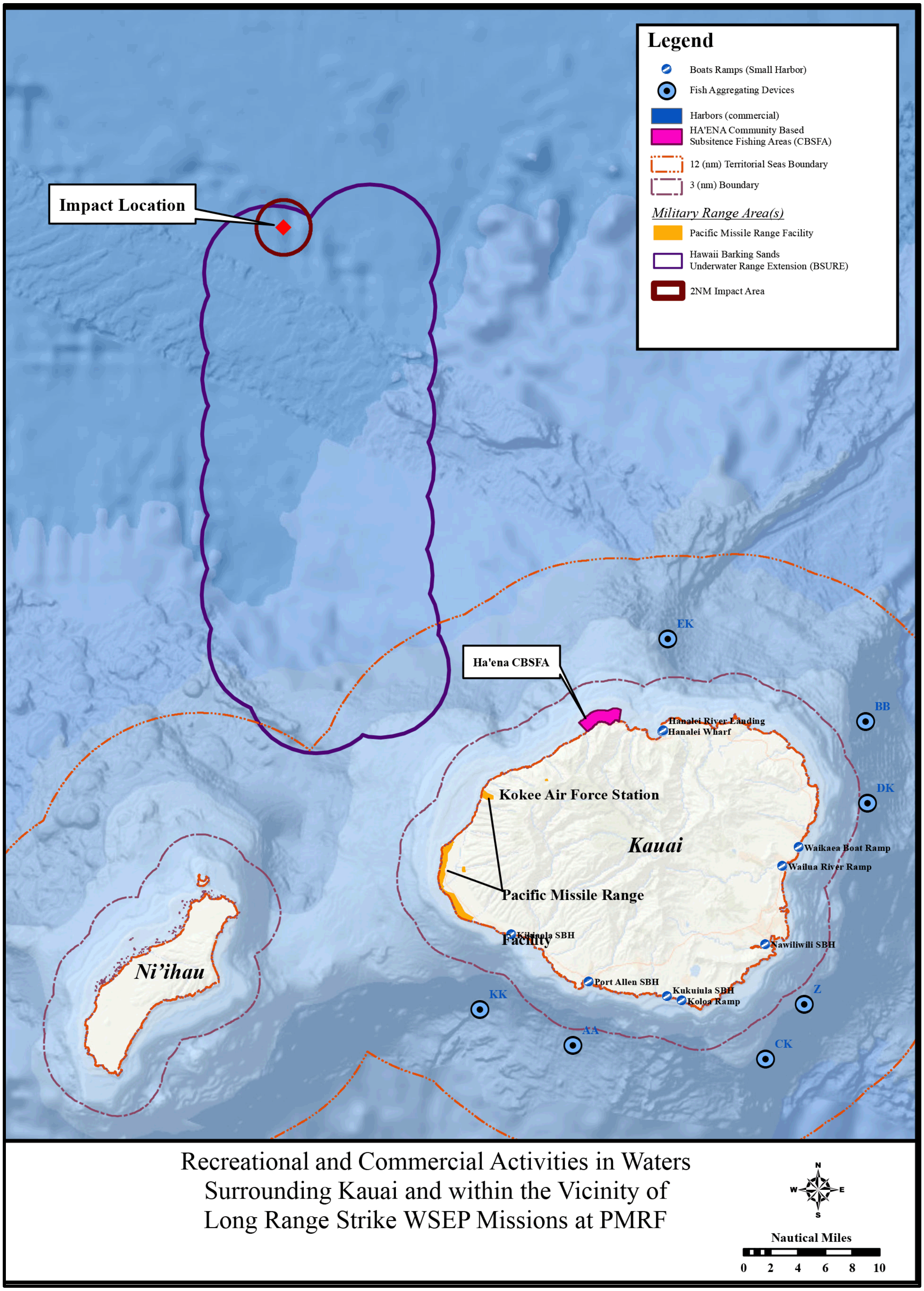
Table 3.5-1. Average Charter Fees and Trip Costs by Trip Type

	Half Day	3/4 Day	Full Day
Ice	$17	$20	$24
Bait	$5	$5	$7
Food/Beverage	$14	$18	$21
Truck Fuel	$7	$6	$7
Boat Fuel	$108	$152	$221
Total Trip Cost (Average for Kauai, Hawaii, Oahu, and Maui Combined)	$151	$201	$280
Total Trip Cost (Kauai Only)	$138	$195	$235
Median Charter Fees (Kauai)	$600	$775	$898

Source: NOAA, 2012

The majority of catch from Kauai charter fishing trips was given away to patrons (47 percent), sold (16 percent) or given away to others (12 percent) while the remaining catch was released (7 percent), consumed at home (6 percent), provided for a community event (6 percent), or traded for goods/services (6 percent) (NOAA, 2012). Kauai's fishing charters mainly depart from the Nawiliwili Harbor or Port Allen Harbor (Figure 3.5-1). Deep sea fishing for different species is considered "good" year-round and peaks according to the different species with the majority of fishing tournaments scheduled between June and August.

Figure 3.5-1. Recreational and Commercial Activities in Waters Surrounding Kauai and the BSURE Area



The island of Kauai offers fishing everywhere due to its location in the middle of the migration pattern of pelagic (open ocean) game fish, natural topography, and deep water close to shore. Deep sea fishing charters departing from Nawiliwili Harbor run from Anahola to Makahuena along the 40 fathom and 1,000 fathom ledges, which can lie as close as 3 NM offshore (Koala Landing Resort, 2013). Many fishermen rely on fish aggregation devices (FADs) to easily locate and catch fish species. As depicted in Figure 3.5-1, there are seven FADs surrounding Kauai, all of which are within 7 NM of the Nawiliwili Harbor along the 1,000 fathom ledges.

Subsistence Use

Subsistence use is defined by the Department of Land and Natural Resources (DLNR) as "the customary and traditional native Hawaiian uses of renewable ocean resources for direct personal or family consumption or sharing" (DLNR, 2014). There are several regulated fishing areas on Kauai, including Hawaii's first Community-Based Subsistence Fishing Area (CBSFA), the Hāʼena CBSFA. The Hāʼena CBSFA is located in State waters extending from the shoreline out to approximately 0.9 NM off the northwestern coast of Kauai (Figure 3.5-1).

Tourism

Total expenditures from visitors to Kauai by air and cruise ship totaled $1.4099 billion in 2014, an increase of 2.3 percent from the previous year. The total number of visitors to Kauai by air was approximately 1.12 million in 2014. Visitors stayed an average of 7.7 days and spent approximately $163.70 daily per person (Hawaii Tourism Authority, 2014). The busiest travel month for arrival to Kauai was July followed by June and January (Hawaii Tourism Authority, 2014). Whale watching is a popular recreation and tourist attraction on Kauai during December to May, peaking between January and April when the Humpback whales migrate to the warmer waters.

Kauai's ocean tour boat industry mainly operates out of the Port Allen small boat harbor. Tours to the Na Pali coast scenery and snorkeling are the main attractions on most Kauai ocean tours with an economic impact of approximately $29.3 million and supporting 420 jobs (NOAA, 2000). Sunset cruises have an economic impact of approximately $6.4 million and supports 92 jobs, while whale watching has an economic impact of $1.6 million and supports 23 jobs (NOAA, 2000).

3.5.3 Environmental Consequences

3.5.3.1 No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur. Long Range Strike WSEP missions would not be conducted, and no live or inert releases of munitions related to Long Range Strike WSEP would occur at PMRF. Socioeconomic conditions would be the same as under baseline conditions, and there would be no impacts to socioeconomics resources under the No Action Alternative.

3.5.3.2 Alternative 1 (Preferred Alternative)

Under this alternative, there would be 10 Air Force personnel on temporary duty (TDY) during each yearly exercise. Personnel would be on TDY for a maximum of five days and would have the option to stay on-base or off-base. PMRF has housing and lodging available for authorized military travelers. If on-base lodging is unavailable at the time of training, Air Force TDY personnel would be able to stay at a TLA-approved hotel in the local community. Based on the hotel occupancy rate of approximately 70 percent, local accommodations in the community would be available to support the temporary personnel and would benefit from additional spending. Any benefits to the local community associated with personnel on TDY would be minor and temporary due to the number of personnel and the length of the assignment.

Based on data from the NMFS, the majority of landings caught commercially occur in the high seas and the majority of recreational angler trips are within 2.6 NM of the shore; both locations are outside the BSURE range. However, Alternative 1 would have the potential to restrict access to the marine environment and temporarily disrupt commercial and recreational fishing, tourism, boating, and other offshore recreational use within the area of the safety footprint during training exercises. Potential restricted access due to the training exercises would last for five consecutive days and up to four hours per day each year. Under this alternative, the Navy would continue to use safety procedures as detailed in Sections 2.1.3 and 3.4.3. Schedule and mission procedures would include NOTMARs and NOTAMs of closures. NOTMARs and NOTAMs would allow commercial and recreational fisherman and ocean boat industries to plan accordingly and mitigate costly delays or cancellations.

As stated in Section 2.2.2, all missions would be conducted during the summer of each year with the exception of 2016 training activities, which would be scheduled for one day in October, on October 20, 2016, with a backup date of October 21, 2016. Recreational activities occur year-round in the offshore waters surrounding Kauai, with the peak whale watching season around Kauai lasting from December to May. August is a popular month for deep sea fishing tournaments. Peak season for deep sea catch of blue marlin, spearfish, blue fin trevally, skipjack tuna (aku), yellowfin tuna (ahi), blue line snapper, and gray snapper occurs in August. Due to Kauai's location and topography, the water depth reaches 1,000 fathoms within 3 NM offshore and FADs are located within 7 NM of Kauai's shoreline. The proximity of tourist activities near shore provides less incentive for recreational boaters and fishermen to travel to distances within W-188A. In addition, the Hā'ena CBSFA is located within 0.87 NM offshore. Therefore, there would be no significant impacts to socioeconomics under Alternative 1.

3.5.3.3 Alternative 2

Under Alternative 2, the only change from Alternative 1 would be the detonation scenarios for weapons that are released. This component of the Proposed Action has no bearing on the timing or size of the marine area that would be closed from commercial and recreational activities. Potential impacts to socioeconomic resources would, therefore, be similar to those as described under Alternative 1. There would be no significant impacts to socioeconomic resources under Alternative 2.

3.6 Cultural Resources

3.6.1 Definition of the Resource

Cultural resources consist of prehistoric and historic sites, structures, artifacts, and any other physical or traditional evidence of human activity considered relevant to a particular culture or community for scientific, traditional, religious, or other reasons.

As defined under 32 CFR 800 (l)(1), "Historic Property means any prehistoric or historic district, site, building, structure, or object included in, or eligible for inclusion in, the NRHP. This term includes artifacts, records, and remains that are related and located within such properties. The term includes properties of traditional religious and cultural importance to an Indian tribe or Native Hawaiian organization and that meet the National Register criteria."

The cultural resources sections in this EA/OEA describe known historic properties within the affected areas that are potentially eligible for the NRHP and evaluate whether elements of the Proposed Action would potentially affect these resources. They include any archaeological resources considered eligible, potentially eligible, or currently listed on the NRHP. This may include shipwrecks, historic structures, historic districts, any known historic cemeteries, traditional cultural properties, or sacred sites.

Attention to cultural resources is necessary for the Air Force to comply with a host of federal laws and regulations, including:

- *The National Historic Preservation Act (NHPA) of 1966, as amended* (54 USC 300101 et seq.). Under NHPA, the Air Force is required to consider the effects of its undertakings on historic properties listed or eligible for listing on the NRHP and to consult with interested parties regarding potential impacts per 36 CFR 800. The regulatory NHPA Section 106 compliance process (54 USC 306108, herein after referred to as Section 106) consists of four primary stages. These include initiation of the Section 106 process (36 CFR 800.3); identification of historic properties (36 CFR 800.4), which includes identifying historic properties potentially affected by a proposed action; assessment of adverse effects (36 CFR 800.5), which determines whether the action would affect historic properties and if effects to those properties might be adverse; and resolution of adverse effects (36 CFR 800.6) between affected and consulting parties such as the SHPO, the Advisory Council on Historic Preservation, Native American tribes, and interested individuals. Additional stipulations are provided for in the NHPA should efforts fail to resolve adverse effects during this process (36 CFR 800.7).
- DoD Instruction 4715.03, *Environmental Conservation Program*, DoD Instruction 4715.16, *Cultural Resources Management*, and Air Force Instruction 32-7065, *Cultural Resources Management*, outlines and specifies procedures for Air Force cultural resource management programs.

Other relevant federal laws and regulations governing cultural resources include:

- Antiquities Act of 1906
- Historic Sites Act of 1935
- Archaeological and Historic Preservation Act of 1974
- Archaeological Resources Protection Act of 1979
- The Submerged Lands Act of 1953
- The Abandoned Shipwreck Act of 1987
- 43 CFR 7, Protection of Archaeological Resources
- 36 CFR 60, NRHP
- 36 CFR 63, Determinations of Eligibility for Inclusion in the National Register

Cultural resource-related Executive Orders that may govern the Proposed Action include:

- EO 11593, Protection and Enhancement of the Cultural Environment
- EO 13287, Preserve America

Two of the significant U.S. laws that address submerged cultural resources are the NHPA and the Abandoned Shipwreck Act of 1987. Section 106 of the NHPA, 1966, as amended, applies to submerged as well as terrestrial cultural resources. Section 106 requires all federal agencies to identify any historic properties that any undertaking has the potential to affect and seek ways to avoid or minimize any adverse effects on these historic properties. Furthermore, eligibility into the NRHP must be determined for these resources. The EEZ extends 200 NM from the shoreline. The Abandoned Shipwreck Act of 1987 gives the title and jurisdiction over historic shipwrecks to the federal government extending to the EEZ. Before engaging in an activity that may negatively affect a shipwreck, this Act requires consideration of the effect the activity may have, often mandating preservation. In consideration of international law, no specific procedures or treaties for identification and protection of cultural resources in the open ocean have been defined to date (DoN, 2013).

Navy undertakings in Hawaii are covered under a Programmatic Agreement (PA) executed in 2003 and amended and restated in 2012 (Hawaii State Historic Preservation Division, 2012). This agreement was reached with the Air Force serving as a consulting party, among others, including the SHPO and National Park Service. Stipulation X.D in the PA specifically addresses submerged resources and directs that any undertakings in areas which potentially may contain submerged cultural resources will involve consultation with the National Park Service, Hawaii SHPO, and Office of Hawaiian Affairs, as appropriate, to develop work and monitoring plans. Stipulation XI.A addresses planning of newly identified resources. If the review of project effects determines that no further review is needed (Section IX.A.1), then no further consideration under the PA and NHPA is required.

Analysis Methodology

This cultural resources section describes known historic properties within the affected areas that are potentially eligible for the NRHP and evaluates whether elements of the Proposed Action and alternatives would potentially affect these resources. They include any archaeological or shipwreck resources considered eligible, potentially eligible, or currently listed on the NRHP.

In this EA/OEA, cultural resources were analyzed by assessing each resource's state of investigation and condition, then evaluating the resource as it intersects with the Area of Potential Effects (APE) for the Proposed Action. As defined under 36 CFR 800.16(d), "the Area of Potential Effects is the geographic area or areas within which an undertaking may directly or indirectly cause changes in the character or use of historic properties, if such properties exist." The APE for this project is equivalent to the biological species impact footprint set forth in this document. This footprint is a 2-NM radius around the target area, in the open ocean area within the BSURE range as detailed in Section 2.1.1 and Appendix A.

Properties identified in the APE by the Air Force are evaluated according to the NRHP criteria, in consultation with the SHPO and other parties. Typically, if the SHPO and other parties and the Air Force agree in writing that a historic property is eligible or not eligible to the NRHP, that judgment is sufficient for purposes of Section 106 (36 CFR 800.4[c][2]). Relevant procedures and criteria can be found in 36 CFR 63, Determinations of Eligibility for Inclusion in the National Register of Historic Places.

The APE within BSURE is located 44 NM northwest of the Island of Kauai (see Figure 1.2-2). BSURE covers approximately 629 NM^2 with the planned impact area located at the northern end of the range. The seafloor depth underneath the target area is 4,645 meters (15,240 feet).

3.6.2 Affected Environment

Approximately 1,500 years ago, seagoing vessels began to arrive at the Hawaiian Islands from various points in Polynesia, beginning a history of extensive maritime traffic in the region. In 1778, Captain James Cook landed on Kauai and introduced European influence in the region. From that time to the mid-1800s with the introduction of merchant activities and whaling, Hawaii has become a major port for Pacific maritime activities. At the turn of the twentieth century, Hawaii became a U.S. territory, with subsequent years witnessing significant growth in maritime traffic from commercial, military, and recreational activities (Hawaii History.org, 2016; NOAA, 2016a; DoN, 2013).

Significant naval activity took place in the Hawaiian Islands during World War II. In addition to the well documented shipwrecks from the Pearl Harbor attack in 1941, there are significant amounts of submerged aviation resources from training activities that took place on the Hawaiian Islands throughout World War II (NOAA, 2016b).

A number of cultural resources data sources were reviewed for this EA/OEA. The shipwreck database maintained by the NOAA Office of Coast Survey Advanced Wreck and Obstruction Information System (AWOIS) was queried for information regarding submerged shipwrecks and obstructions. Previous environmental documents, such as the *Hawaii-Southern California Training and Testing Final*

Environmental Impact Statement/Overseas Environmental Impact Statement (2013), and other written and online documents were reviewed as a baseline for previous research. The World Heritage List was reviewed for any properties listed near the project area (United Nations Educational, Scientific and Cultural Organization [UNESCO], 2016). The National Register Information System (NRIS) and Hawaii SHPO online resources were also reviewed for any relevant information.

Due to the distance offshore of the Proposed Action (44 NM), the primary cultural resource concern would be shipwrecks. There are a number of known wrecks and obstructions in the region; however none of these are within the APE (Figure 3.6-1; NOAA, 2016c). The nearest known wreck is located 4 NM northeast of the impact location and 1 NM outside the northern boundary of the BSURE range.

The APE contains no submerged sites eligible for or listed on the NRHP. The only submerged NRHP-eligible sites in Hawaii are located at Pearl Harbor, outside of the APE. The Papahanaumokuakea Marine National Monument is the nearest World Heritage Site but is also outside of the APE for the Proposed Action (DoN, 2013). Nominated to the World Heritage List in July 2010, Papahanaumokuakea has a total area of 362,075 square kilometers and is one of the largest protected marine areas in the world. The site is considered significant to Native Hawaiian populations for religious and cultural reasons (UNESCO, 2016).

3.6.1 Environmental Consequences

Submerged cultural resources could be impacted from the Proposed Action by two potential types of stressors. The first is from direct physical impacts where expended materials come into contact with submerged cultural sites. The second would be acoustic stressors that could impact submerged cultural resources through the shockwave generated by underwater detonations. These stressors would be impacted by factors such as depth, the size and the nature of the explosive charge.

3.6.1.1 No Action Alternative

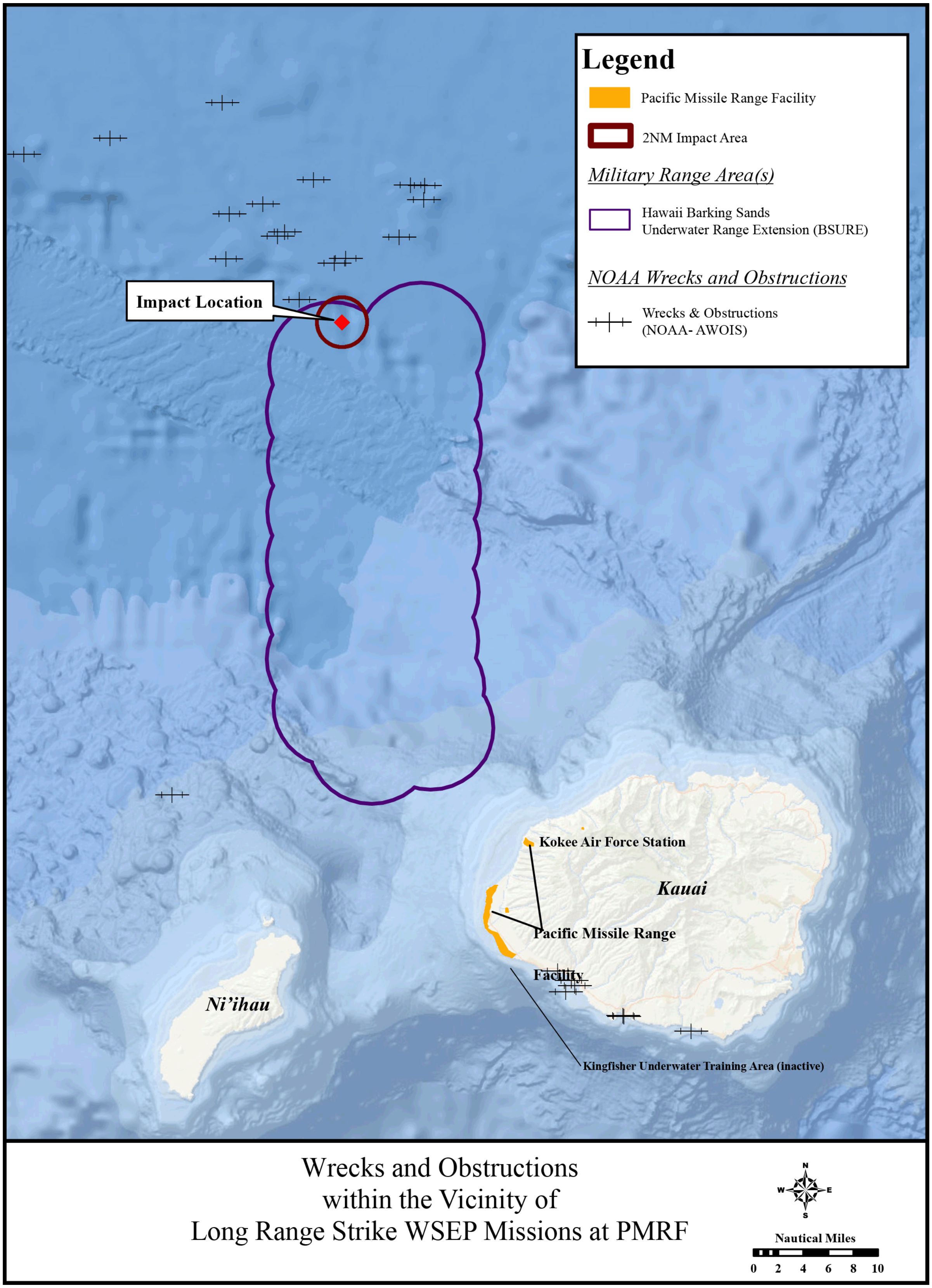
Under the No Action Alternative, activities associated with the long range strike WSEP operational evaluations would not occur in the offshore waters of Hawaii. As a result, no effects to submerged cultural resources would be anticipated as a result of the No Action Alternative.

3.6.1.2 Alternative 1 (Preferred Alternative)

No cultural resources would be affected by activities proposed under Alternative 1. This alternative is consistent with activities currently being conducted by other users of the PMRF. In compliance with the current Programmatic Agreement in effect at PMRF, no impacts by underwater detonations at depth are expected within U.S. territorial waters and no world heritage sites would be affected. No deep sea shipwrecks or cultural features have been identified within the APE for the Long Range Strike WSEP missions. In addition to the lack of historic properties within the APE, munitions utilized under Alternative 1 would detonate at the surface or 3 meters (10 feet) below the water surface. In the case of underwater detonations, overpressure generated by these munitions will not impact cultural resources on the seafloor due to a seafloor depth of 4,645 meters (15,240 feet) at the target location. It is also highly unlikely that military expended materials or UXO from ordnance could sink and directly impact sediments on or near cultural resources or affect any shipwrecks. If any unidentified properties are discovered or unanticipated effects were to result from the alternatives presented in this document, the Air Force will take measures reasonably available to protect these areas.

The Air Force presented a letter to the Hawaii SHPO on March 30, 2016, with a finding of No Effect on Historic Properties, as defined in 36 CFR 800.16(i). The Air Force provided documentation of this finding to the SHPO, as required by 36 CFR 800.11(d). The Hawaii SHPO concurred with this finding of No Effect on Historic Properties in a letter dated April 20, 2016. Both letters are included in Appendix A of this document.

Figure 3.6-1. Wrecks and Obstructions Within the Vicinity of Long Range Strike WSEP Missions at PMRF



3.6.1.3 Alternative 2

Environmental consequences resulting from implementation of Alternative 2 would be nearly identical to those presented under Alternative 1. No cultural resources would be affected by activities proposed under Alternative 2. No deep sea shipwrecks or cultural features have been identified within the APE. Munitions deployed under Alternative 2 would be limited to air and surface detonations. As with Alternative 1, it is highly unlikely that debris or UXO from ordnance or portions of targets could sink and directly impact sediments on or near cultural resources or affect any shipwrecks.

3.7 Physical Resources

3.7.1 Definition of the Resource

Physical resources evaluated in this document include open ocean waters and underlying sediments.

3.7.2 Affected Environment

Physical resources evaluated in this document include the W-188(A) water column and underlying sediments, located within the Open Ocean Area off the Hawaiian Islands (Figure 1.2-2). The final impact point is within the BSURE area, approximately 44 NM offshore of Kauai and is, therefore, outside of the 12-NM State water boundary.

Within the portion of the BSURE that is beyond 12 NM from shore, unconsolidated sediments settle from the overlying water column to create a deep, smooth layer over the underlying volcanic bedrock of the abyssal plain. Sediments are typically marine (carbonate) or volcanic in origin and range from coarse textured shell, coral, and lava fragments in shallower waters to fine siliceous and calcareous oozes in the deep waters. Cobbles formed of precipitate manganese may also be present, but no seamounts (isolated rocky features where magma has erupted to form an outcrop) are found in the BSURE area (U.S. Navy, 2005).

Waters of the open ocean near the Hawaiian Islands exceed depths of 20,000 feet in places, and the water at the proposed test site is approximately 15,240 feet deep. Water quality in the pelagic zone is excellent, with low amounts of suspended material, high water clarity, high dissolved oxygen levels, and low concentrations of hydrocarbons and trace metals (U.S. Navy, 2002). Salinity of these open ocean waters is approximately 35 parts per thousand. Average water temperatures range from 71° F in March to 81°F in September. Wave height can occasionally exceed 40 feet during high winds, but swell typically range from about 3 to 10 feet.

3.7.3 Environmental Consequences

Physical resources (substrate and the water column) could be affected by direct impacts or by metals and chemical materials introduced through spent munitions, explosive byproducts, military expended materials, or air-to-air refueling.

3.7.3.1 No Action Alternative

Under the No Action Alternative, Long Range Strike WSEP activities would not take place. No detonations would occur, and no materials would be introduced into the water. There would be no impacts to physical resources. The No Action Alternative would not meet the purpose and need for the Proposed Action.

3.7.3.2 Alternative 1 (Preferred Alternative)

Metals typically used to construct bombs and missiles include aluminum and steel. Aluminum is also present in some explosive materials such as tritonal and AFX-757. Metals would settle to the seafloor after munitions are detonated. Metal ions would slowly leach into the substrate and the water column, causing elevated concentrations in a small area around munitions fragments. Some of the metals, such as aluminum, occur naturally in the ocean at varying concentrations and would not necessarily impact the substrate or water column. Other metals could cause toxicity in microbial communities in the substrate. However, such effects would be localized and would not significantly affect the overall habitat quality of sediments in the BSURE area. In addition, metal fragments would corrode, degrade, and become encrusted over time.

Explosive byproducts would be introduced into the water column through detonation of live munitions. Explosive materials associated with Long Range Strike WSEP munitions include tritonal and research department explosive (RDX), among others. Tritonal is primarily composed of TNT. Various byproducts are produced during and immediately after detonation of RDX. During the very brief time that a detonation is in progress, intermediate products may include carbon ions, nitrogen ions, oxygen ions, water, hydrogen cyanide, carbon monoxide, nitrogen gas, nitrous oxide, cyanic acid, and carbon dioxide (Becker, 1995). However, reactions quickly occur between the intermediates, and the final products consist mainly of water, carbon monoxide, carbon dioxide, and nitrogen gas, although small amounts of other compounds may be produced as well.

Chemicals introduced to the water column would be quickly dispersed by waves, currents, and tidal action and eventually be distributed throughout the surrounding open ocean waters. A portion of the carbon compounds, such as carbon monoxide and carbon dioxide, would likely become integrated into the carbonate system (alkalinity and pH buffering capacity of seawater). Some of the nitrogen and carbon compounds would be metabolized or assimilated during protein synthesis by phytoplankton and bacteria. Most of the gaseous products that do not react with the water or become assimilated by organisms would be released to the atmosphere. Due to dilution, mixing, and transformation, none of these chemicals are expected to have significant impacts on the marine environment.

Explosive material that is not consumed in a detonation could sink to the substrate and bind to sediments. However, the quantity of such materials is expected to be inconsequential. When munitions function properly, nearly full combustion of the explosive materials occurs, and only extremely small amounts of raw material remain. Additionally, TNT decomposes when exposed to sunlight/ultraviolet radiation and is also degraded by microbial activity (Becker, 1995). Several types of microorganisms have been shown to metabolize TNT. Similarly, RDX is decomposed by hydrolysis, ultraviolet radiation exposure, and biodegradation.

Direct physical impacts to the seafloor could occur due to military expended materials and detonation shock waves. Military expended materials deposited on the seafloor would include spent ordnance fragments and inert munitions. Military expended materials moved by water currents could scour the bottom, but sediments would quickly refill any affected areas, and overall effects to benthic communities would be minor. Large pieces of military expended materials would not be as prone to movement on the seafloor and could result in beneficial effects by providing habitat for encrusting organisms, fish, and other marine fauna. Overall, the quantity of material deposited on the seafloor would be small compared with other sources of debris in the Open Ocean Area off the Hawaiian Islands. No natural or artificial reefs are located in the vicinity of the mission site, so no reefs would be affected by military expended materials.

Underwater detonations produce pressure waves that may displace sediments and possibly cause cratering if these waves reach the seafloor. Equations for determining the radius of a crater due to underwater explosions on the seafloor are provided by O'Keefe and Young (1984). However, the equations for seafloor detonations cannot be directly applied to detonations in the water column. In this case (and when the detonation occurs in relatively deep water), the radius of the explosive gas bubble may be considered a reasonable approximation of the radius of a crater if the detonation were to occur on the seafloor. Based on this association, the bubble radius of detonations in the water column is used to determine impacts to bottom sediments. If the radius extends to the seafloor, then impacts to the sediment would likely occur. If, however, the radius does not reach the bottom, then no impacts to sediment would be considered.

Swisdak (1978) provides the equation for the maximum radius of a gas bubble as:

$A_{max} = (J)\ (W^{.33}/[H+Ho]^{.33})$

Where:

A_{max} = maximum bubble radius (meters)

J = bubble coefficient, which for TNT is 3.5 $m^{4/3}/kg^{1/3}$

W = charge weight (kilograms [kg])

H = depth of explosion (m)

Ho = atmospheric head, which equals 10 meters

For Alternative 1, the only subsurface detonation scenario would involve JDAM/LJDAM, which has 192 pounds (87.09 kg) of TNT-equivalent NEW. The depth of underwater detonation for the JDAM/LJDAM missiles would be 10 feet (3.05 meters) beneath the surface. The equation above calculates a maximum bubble radius from a 10-foot deep JDAM/LJDAM detonation to be 6.6 meters, or 21.7 feet. Given the water depth at the target location to be approximately 4,645 meters (15,240 feet), the explosive bubble radius would not extend to the seafloor and, thus, would not cause sediment displacement or cratering.

Air-to-air refueling operations are typically conducted at high altitudes ranging from 16,000 to 26,000 feet for receiving aircraft. Fuel dispensing aircraft are fitted with instantaneous, automatic closure devices (poppet valves) to reduce fuel loss during transfers. Estimates of fuel losses during refueling events are on the order of one quart during normal transfers and one- to two-gallons or less during unplanned, emergency breakaways. This small amount of fuel would evaporate before fuel reached the water. Adverse impacts to water resources from fuel releases are not anticipated.

In summary, there would be no significant impacts to physical resources from Alternative 1.

3.7.3.3 Alternative 2

Under Alternative 2, impacts to physical resources would be similar to those described for Alternative 1, minus any impacts from subsurface JDAM/LJDAM detonations. Resources may be affected by metals and chemical materials introduced through spent munitions and explosive byproducts and by direct impacts, but at a lesser degree than under Alternative 1. There would be no significant impacts to physical resources under Alternative 2.

3.8 Biological Resources

3.8.1 Definition of the Resource

This section describes the biological environment of the study area, which consists of the PMRF with an emphasis on the BSURE area (where missions would occur) when specific information is available. The *biological environment* refers to living resources that use the water surface, water column, and substrates underlying the PMRF, as well as the habitats in which they occur. These resources include marine mammals, sea turtles, marine fish, and essential fish habitat (i.e., EFH). This section includes information on special status species, which are those protected by federal laws such as the ESA and MMPA (described in Section 1.6, *Relevant Laws and Regulations*). Seabird species, including species protected under the ESA and MBTA, occur in the Hawaii region and, therefore, potentially occur in the Study Area. However, due to the relatively low number of total detonations, including a very low number of in-air detonations (four per year), the likelihood of birds being present at the impact area at the time of an explosion is considered remote. In addition, there would be no on-water targets to provide resting surfaces for birds. Therefore, seabirds are not considered further in this document.

Analysis Methodology

Analysis considers potential impacts to biological resources, including habitats and special status species. The analyses primarily include an assessment of potential impacts resulting from munitions detonations (noise and pressure effects), physical strike, ingestion stressors, and alteration of the water column and seafloor. Effects to marine species may potentially occur in the form of mortality, injury, harassment, or behavioral modifications. Where appropriate, projected conditions are compared with baseline conditions.

3.8.2 Affected Environment

3.8.2.1 Marine Mammals

This subsection describes marine mammals that are potentially found in the PMRF, including the BSURE area (referred to as the study area). In some instances, references are made to various regions of the Pacific Ocean delineated by the NOAA/NMFS (NMFS) Science Centers. The central north Pacific is considered to be the area north of the equator and between the International Date Line (180 degrees [°] west [W] longitude) and 140° W longitude.

Marine mammals are a diverse group of approximately 130 species that rely wholly or substantially on the sea for important life functions and include cetaceans (whales, dolphins, and porpoises), pinnipeds (seals, sea lions, and walruses), sirenians (manatees, dugongs, and sea cows), marine otters, and polar bears. Of these animal groups, only whales, dolphins, and one pinniped occur in the study area. Although most marine mammal species live predominantly in the marine habitat, some spend time in terrestrial habitats (e.g., seals) or freshwater environments (e.g., river dolphins). All marine mammals in the United States are protected under the MMPA; some species are additionally protected under the ESA. Marine mammals may be designated under the ESA as endangered, threatened, candidate, or proposed species. Under the MMPA, species may be designated as depleted, which is defined as a species or stock that is (1) below its optimum sustainable population or (2) designated as endangered or threatened under the ESA.

Cetaceans may be categorized as odontocetes or mysticetes. Odontocetes, which range in length from about 1 meter to over 18 meters, have teeth that are used to capture and consume individual prey. Mysticetes, known as baleen whales, range in length from about 10 meters to over 30 meters. Instead of teeth, mysticetes have baleen (a fibrous structure made of keratin) in their mouths that is used to filter the large numbers of small prey that are engulfed, sucked, or skimmed from the water or ocean floor sediments.

Cetaceans inhabit virtually every marine environment, from coastal waters to the open ocean. Their distribution is primarily influenced by prey availability, which depends on factors such as ocean current patterns, bottom relief, and sea surface temperature. Most of the large cetaceans are migratory, but many small cetaceans do not migrate in the strictest sense. Instead, they undergo seasonal dispersal, or shifts in density. Pinnipeds generally spend a large portion of time on land at haul-out sites, used for resting and moulting, and at rookeries, used for breeding and nursing young, and return to the water to forage. The only pinniped species that occurs regularly in Hawaii is the Hawaiian monk seal (*Neomonachus schauinslandi*). In the Main Hawaiian Islands, they are generally solitary and have no established rookeries.

General Behavior

Many species of marine mammals, particularly odontocetes, are highly social animals that spend much of their lives living in groups or schools ranging from several individuals to several thousand individuals. Aggregations of baleen whales may form during particular breeding or foraging seasons, although they do not appear to persist over time as a social unit. All marine mammals dive beneath the water surface, primarily for the purpose of foraging. Dive frequency and duration vary among species and within individuals of the same species. Some species that forage on deep-water prey can make dives lasting over an hour. Other species spend the majority of their lives close to the surface and make relatively shallow dives. The diving behavior of a particular species or individual has implications for the ability to detect them during mitigation and monitoring activities. In addition, their distribution through the water column is an important consideration when conducting acoustic exposure analyses.

Vocalization and Hearing

All marine mammals that have been studied can produce sounds and use sounds to forage, orient, detect, and respond to predators and socially interact with others. Measurements of marine mammal sound production and hearing capabilities provide some basis for assessment of whether exposure to a particular sound source may affect a marine mammal. Marine mammal hearing abilities are quantified using live animals either via behavioral audiometry or electrophysiology.

Behavioral audiograms are plots of animals' exhibited hearing threshold versus frequency and are obtained from captive, trained live animals. Behavioral audiograms are difficult to obtain because many species are too large, too rare, and too difficult to acquire and maintain for experiments in captivity. Electrophysiological audiometry measures small electrical voltages produced by neural activity when the auditory system is stimulated by sound. The technique is relatively fast, does not require a conscious response, and is routinely used to assess the hearing of newborn humans.

Understanding of a species' hearing ability may be based on the behavioral audiogram of only a single individual or small group of animals. In addition, captive animals may be exposed to local ambient sounds and other environmental factors that may impact their hearing abilities and may not accurately reflect the hearing abilities of free-swimming animals (Houser et al., 2010). For animals not available in captive or stranded settings (including large whales and rare species), estimates of hearing capabilities are made based on physiological structures, vocal characteristics, and extrapolations from related species.

Direct measurement of hearing sensitivity exists for only about 25 of the nearly 130 species of marine mammals. Table 3.8-1 summarizes sound production and general hearing capabilities for marine mammals with potential occurrence in the study area. For purposes of the analyses in this document, marine mammals are arranged into the following functional hearing groups based on their generalized hearing sensitivities: high-frequency cetaceans, mid-frequency cetaceans, low-frequency cetaceans (mysticetes), and phocid pinnipeds (true seals). For a detailed discussion of all marine mammal functional hearing groups and their derivation, see Finneran and Jenkins (2012).

Table 3.8-1. Hearing and Vocalization Ranges for Marine Mammal Functional Hearing Groups and Species Potentially Occurring in the Study Area

Functional Hearing Group	Species Potentially Present in the Study Area	Sound Production		General Hearing Ability Frequency Range
		Frequency Range	Source Level (dB re 1 μPa @ 1 m)	
High-frequency cetaceans	*Kogia* species (dwarf sperm whale and pygmy sperm whale)	100 Hz to 200 kHz	120 to 205	200 Hz to 180 kHz
Mid-frequency cetaceans	Sperm whale, beaked whales (*Indopacetus*, *Mesoplodon*, and *Ziphius* species), Bottlenose dolphin, Fraser's dolphin, killer whale, false killer whale, pygmy killer whale, melon-headed whale, short-finned pilot whale, Risso's dolphin, rough-toothed dolphin, spinner dolphin, pantropical spotted dolphin, striped dolphin	100 Hz to >100kHz	118 to 236	150 Hz to 160 kHz
Low-frequency cetaceans	Blue whale, Bryde's whale, fin whale, humpback whale, minke whale, sei whale	10 Hz to 20 kHz	129 to 195	7 Hz to 22 kHz
Phocidae	Hawaiian monk seal	100 Hz to 12 kHz	103 to 180	In water: 75 Hz to 75 kHz In air: 75 Hz to 30 kHz

dB re 1 μPa @ 1 m = decibels referenced to 1 micropascal at 1 meter; Hz = hertz; kHz = kilohertz

General Threats

Marine mammal populations can be influenced by various factors and human activities. These factors can affect marine mammal populations directly (e.g., hunting and whale watching) or indirectly (e.g., reduced prey availability or lowered reproductive success). Marine mammals may also be influenced by natural phenomena such as storms and other extreme weather patterns and climate change. Generally, not much is known about how large storms and other weather patterns affect marine mammals, other than that mass strandings (when two or more marine mammals become beached or stuck in shallow water) sometimes coincide with hurricanes, typhoons, and other tropical storms (Marsh, 1989; Rosel and Watts, 2008). Climate change can potentially affect marine mammal species directly through habitat loss (especially for species that depend on ice or terrestrial areas) and indirectly via impacts on prey, changing prey distributions and locations, and changes in water temperature.

Mass die-offs of some marine mammal species have been linked to toxic algal blooms. In such cases, the mammals consume prey that has consumed toxic plankton. All marine mammals have parasites that, under normal circumstances, probably do little overall harm but that under certain conditions can cause health problems or even death (Jepson et al., 2005; Bull et al., 2006; Fauquier et al., 2009). Disease affects some individuals (especially older animals), and occasionally disease epidemics can injure or kill a large percentage of a population (Paniz-Mondolfi and Sander-Hoffmann, 2009; Keck et al., 2010). Recently, the first case of morbillivirus in the central Pacific was documented for a stranded Longman's beaked whale at Maui (West et al., 2012).

Human impacts on marine mammals have received much attention in recent decades and include hunting (both commercial and native practices), fisheries interactions (such as gear entanglement or shootings by fishers), by-catch (accidental or incidental catch), indirect effects of fisheries through takes of prey species, ship strikes, noise pollution, chemical pollution, and general habitat deterioration or destruction. Direct hunting, as in whaling and sealing operations, provided the original impetus for marine mammal management efforts and has driven much of the early research on cetaceans and pinnipeds (Twiss and Reeves, 1999). In 1994, the MMPA was amended to formally address by-catch. Cetacean by-catch subsequently declined by 85 percent between 1994 and 2006. However, fishery by-catch is likely the most impactful problem presently and may account for the deaths of more marine mammals than any other cause (Northridge, 2008; Read, 2008; Hamer et al., 2010; Geijer and Read, 2013). For example, by-catch has significantly contributed to the decline of the Hawaiian population of false killer whales (Boggs et al., 2010).

Ship strikes are an issue of increasing concern for most marine mammals, particularly baleen whale species. There were nine reported ship collisions with humpback whales in the Hawaiian Islands in 2006 (none involved Navy vessels), as recorded by the NMFS Pacific Islands Region Marine Mammal Response Network Activity Updates (NMFS, 2007a). Overall, there were 39 vessel collisions involving humpback whales in Hawaii from 2007 to 2012 (Bradford and Lyman, 2015). None of these strikes involved Navy vessels. A humpback carcass was discovered on the shore of southwest Molokai in 2010 with indications that the death resulted from trauma consistent with a ship strike (NMFS, 2010e).

Chemical pollution is also of great concern, although for the most part, its effects on marine mammals are not well understood (Aguilar de Soto et al., 2008). Chemical pollutants found in pesticides flow into the marine environment from human use on land and are absorbed into the bodies of marine mammals, accumulating in their blubber or internal organs, or are transferred to the young from its mother's milk (Fair et al., 2010). Marine mammals that live closer to the source of pollutants and feed on higher-level organisms have increased potential to accumulate toxins (Moon et al., 2010). The buildup of human-made persistent compounds in marine mammals not only increases their likelihood of contracting diseases or developing tumors, but it also compromises the function of their reproductive systems (Fair et al., 2010). Oil and other chemical spills are a specific type of ocean contamination that can have damaging effects on some marine mammal species (see Matkin et al., 2008).

Habitat deterioration and loss is a major factor for almost all coastal and inshore species of marine mammals, especially those that live in rivers or estuaries, and it may include such factors as depleting a habitat's prey base and the complete loss of habitat (Kemp, 1996; Smith et al., 2009; Ayres et al., 2012). In some locations, especially where urban or industrial activities or commercial shipping is intense, anthropogenic noise is also being increasingly considered as a potential habitat-level stressor. Noise is of particular concern to marine mammals because many species use sound as a primary sense for navigating, finding prey, avoiding predators, and communicating with other individuals. Noise may cause marine mammals to leave a habitat, impair their ability to communicate, or cause stress (Hildebrand, 2009; Tyack et al., 2011; Rolland et al., 2012; Erbe et al., 2012). Noise can cause behavioral disturbances, mask other sounds (including their own vocalizations), may result in injury and, in some cases, may result in behaviors that ultimately lead to death (National Research Council, 2003, 2005; Nowacek et al., 2007; Würsig and Richardson, 2009; Southall et al., 2009; Tyack, 2009a).

Anthropogenic noise is generated from a variety of sources including commercial shipping, oil and gas activities, commercial and recreational fishing, recreational boating and whale watching, offshore power generation, research (including sound from air guns, sonar, and telemetry), and military training and testing activities. Vessel noise, in particular, is a large contributor to noise in the ocean. Commercial shipping's contribution to ambient noise in the ocean has increased by as much as 12 dB over the last few decades (McDonald et al., 2008; Hildebrand, 2009).

Marine mammals as a whole are subject to the various influences and factors described above. If additional specific threats to individual species within the study area are known, those threats are described below in the descriptive accounts of those species.

General Occurrence in the Study Area

The MMPA defines a marine mammal "stock" as "a group of marine mammals of the same species or smaller taxon in a common spatial arrangement that interbreed when mature." For MMPA management purposes, a *stock* is considered an isolated population or group of individuals within a whole species that is found in the same area. However, due to lack of sufficient information, NMFS-recognized management stocks may include groups of multiple species. There are 25 marine mammal species with potential occurrence in the study area, including 6 mysticetes (baleen whales), 18 odontocetes (dolphins and toothed whales), and 1 pinniped. Multiple stocks are designated in the Hawaii region for some of these species, resulting in a total of 40 stocks managed by NMFS or the USFWS in the U.S. EEZ off the coast of Hawaii (hereafter referred to as the Hawaiian Islands EEZ.

Many of the stock boundaries are based on water depth or distance from shore. Therefore, due to the Long Range Strike WSEP impact site location, not all stocks coincide with the mission area. Certain stocks of melon-headed whale, bottlenose dolphin, pantropical spotted dolphin, and spinner dolphin are excluded based on these criteria. Three false killer whale stocks occur in the vicinity of the Hawaiian Islands. The offshore boundary of the Main Hawaiian Islands Insular stock is delineated at a maximum distance of 39 NM (72 kilometers) offshore. For 2017–2021 missions, the behavioral harassment range associated with detonations extends into this stock boundary by less than 2 kilometers. The remaining two false killer whale stocks (Northwestern Hawaiian Islands and Hawaii Pelagic) occur within areas potentially affected by detonations as well. Therefore, all false killer whale stocks are included in this document.

Species for which some stocks in the Hawaii region are excluded from consideration, along with the rationale for inclusion or exclusion, is provided in Table 3.8-2.

Table 3.8-2. Occurrence of Marine Mammal Species with Multiple Designated Stocks

Species	Stock[1]	Stock Boundary Designation	Occurrence in Mission Area (44 NM/81 km offshore; water depth 4,645 m)	
			Present	Not Present
False killer whale (*Pseudorca crassidens*)	Main Hawaiian Islands Insular	Animals inhabiting waters within 39 NM (72 km) of the Main Hawaiian Islands	X	
	Northwestern Hawaiian Islands	Animals inhabiting waters within a 50-NM (93-km) radius of the Northwestern Hawaiian Islands, or the boundary of the Papahānaumokuākea Marine National Monument, with the radial boundary extended to the southeast to encompass Kauai and Niihau	X	
	Hawaii Pelagic	Animals inhabiting waters greater than 6 NM (11 km) from the Main Hawaiian Islands (there is no inner	X	

Table 3.8-2. Occurrence of Marine Mammal Species with Multiple Designated Stocks (Cont'd)

Species	Stock[1]	Stock Boundary Designation	Occurrence in Mission Area (44 NM/81 km offshore; water depth 4,645 m)	
			Present	Not Present
		boundary within the Northwestern Hawaiian Islands)		
Melon-headed whale (*Peponocephala electra*)	Hawaiian Islands	Animals inhabiting waters throughout the U.S. EEZ of the Hawaiian Islands	X	
	Kohala Resident	Animals off the Kohala Peninsula and west coast of Hawaii Island and in less than 2,500-m water depth		X
Bottlenose dolphin (*Tursiops truncatus*)	Hawaii Pelagic	Animals inhabiting waters throughout the U.S. EEZ of the Hawaiian Islands	X	
	Kauai and Niihau Oahu 4-Island Hawaii Island	Animals occurring from the shoreline of the respective islands to 1,000-m water depth		X
Pantropical spotted dolphin (*Stenella attenuata*)	Hawaii Pelagic	Animals inhabiting waters throughout the U.S. EEZ of the Hawaiian Islands, outside of the insular stock areas	X	
	Oahu 4-Island	Animals occurring from the shoreline of the respective islands to 20 km offshore		X
	Hawaii Island	Animals occurring from the shoreline to 65 kilometers offshore of Hawaii Island		X
Spinner dolphin (*Stenella longirostris*)	Hawaii Pelagic	Animals inhabiting waters throughout the U.S. EEZ of the Hawaiian Islands, outside of island-associated stock boundaries	X	
	Hawaii Island Oahu and 4-Island Kauai and Niihau Midway Atoll/Kure Pearl and Hermes Reef	Animals occurring within 10 NM (19 km) of shore of the respective islands		X

km = kilometers; m = meters; NM = nautical miles
1. Stock designations and boundaries were obtained from Carretta et al., 2016.

All species and stocks occurring in the Hawaii region are presented in Table 3.8-3. The following subsections describe each marine mammal species based on the most recent stock assessment report, including status and management, geographic range and distribution, population and abundance, predator/prey interactions, and species-specific threats. Since marine mammals are federally protected under the MMPA, and potentially under the ESA as well, these species descriptions follow the framework for assessing impacts and making determinations under these laws and are also included in the respective consultation documents (e.g., IHA request, LOA request, and Biological Assessment). The North Pacific right whale (*Eubalaena japonica*) is not included in the table or in impacts analyses provided later in this document. This species is considered "vagrant" in the area, as the Hawaii region is currently outside the typical geographic range (Reilly et al., 2008). The most recent known sightings in the Hawaii region occurred in 1996 and 1979 (Salden and Mickelsen, 1999; Herman et al., 1980; Rowntree et al., 1980).

Table 3.8-3. Marine Mammals with Potential Occurrence in the Study Area

Common Name	Scientific Name	Stock	Stock Abundance (CV)[4]	Study Area Abundance (CV)[4]	Occurrence	ESA/MMPA Status
Mysticetes (baleen whales)						
Humpback whale[1]	*Megaptera novaeangliae*	Central North Pacific	10,103 (N/A)	4,491 (N/A)	Seasonal; throughout known breeding grounds during winter and spring (most common November through April).	Endangered/depleted
Blue whale[2]	*Balaenoptera musculus*	Central North Pacific	81 (summer/fall) (1.14)	81 (summer/fall) (1.14)	Seasonal; infrequent winter migrant; few sightings, mainly fall and winter; considered rare.	Endangered/depleted
Fin whale[2]	*Balaenoptera physalus*	Hawaii	58 (summer/fall) (1.12)	58 (summer/fall) (1.12)	Seasonal, mainly fall and winter; considered rare.	Endangered/depleted
Sei whale[2]	*Balaenoptera borealis*	Hawaii	178 (summer/fall) (0.90)	178 (summer/fall) (0.90)	Rare; limited sightings of seasonal migrants that feed at higher latitudes.	Endangered/depleted
Bryde's whale[2]	*Balaenoptera brydei/edeni*	Hawaii	798 (0.28)	798 (0.28)	Uncommon; distributed throughout the Hawaiian EEZ.	N/A
Minke whale[2]	*Balaenoptera acutorostrata*	Hawaii	No data	No data	Regular but seasonal (October–April).	N/A

Table 3.8-3. Marine Mammals with Potential Occurrence in the Study Area (Cont'd)

Common Name	Scientific Name	Stock	Stock Abundance (CV)[4]	Study Area Abundance (CV)[4]	Occurrence	ESA/MMPA Status
Odontocetes (toothed whales and dolphins)						
Sperm whale[2]	*Physeter macrocephalus*	Hawaii	3,354 (0.34)	3,354 (0.34)	Widely distributed year-round; more likely in waters > 1,000-m depth, most often > 2,000 m.	Endangered/depleted
Pygmy sperm whale[2]	*Kogia breviceps*	Hawaii	No data	No data	Stranding numbers suggest this species is more common than previous survey sightings indicated.	N/A
Dwarf sperm whale[2]	*Kogia sima*	Hawaii	No data	No data	Stranding numbers suggest this species is more common than previous survey sightings indicated.	N/A
Killer whale[2]	*Orcinus orca*	Hawaii	101 (1.00)	101 (1.00)	Uncommon; infrequent sightings.	N/A
False killer whale Hawaiian Islands Stock Complex[3]	*Pseudorca crassidens*	Main Hawaiian Islands Insular	151 (0.20)	151 (0.20)	Regular.	Endangered/depleted
		Hawaii Pelagic	1,540 (0.67)	1,540 (0.67)	Regular.	N/A
		Northwestern Hawaiian Islands	617 (1.11)	617 (1.11)	Regular.	N/A
Pygmy killer whale[2]	*Feresa attenuata*	Hawaii	3,433 (0.52)	3,433 (0.52)	Year-round resident.	N/A
Short-finned pilot whale[2]	*Globicephala macrorhynchus*	Hawaii	12,422 (0.43)	12,422 (0.43)	Commonly observed around Main Hawaiian Islands and Northwestern Hawaiian Islands.	N/A
Melon-headed	*Peponocephala electra*	Hawaii Islands	5,794 (0.20)	5,794 (0.20)	Regular.	N/A

Table 3.8-3. Marine Mammals with Potential Occurrence in the Study Area (Cont'd)

Common Name	Scientific Name	Stock	Stock Abundance (CV)[4]	Study Area Abundance (CV)[4]	Occurrence	ESA/MMPA Status
whale Hawaiian Islands Stock Complex[2]		Kohala Resident	447 (0.12)	Not applicable to study area	Regular.	N/A
Bottlenose dolphin Hawaiian Islands Stock Complex[2]	*Tursiops truncatus*	Hawaii Pelagic	5,950 (0.59)	5,950 (0.59)	Common in deep offshore waters.	N/A
		Kauai and Niihau	147 (0.11)	Not applicable to study area	Common in shallow nearshore waters ≤ 1,000-m depth).	N/A
		Oahu	594 (0.54)	Not applicable to study area	Common in shallow nearshore waters ≤ 1,000-m depth).	N/A
		4-Island	153 (0.24)	Not applicable to study area	Common in shallow nearshore waters ≤ 1,000-m depth).	N/A
		Hawaii Island	102 (0.13)	Not applicable to study area	Common in shallow nearshore waters ≤ 1,000-m depth).	N/A
Pantropical spotted dolphin Hawaiian Islands Stock Complex[2]	*Stenella attenuata*	Hawaii Pelagic	15,917 (0.40)	15,917 (0.40)	Common; primary occurrence between 100- and 4,000-m depth.	N/A
		Oahu	No data	Not applicable to study area	Common; primary occurrence between 100- and 4,000-m depth.	N/A
		4-Island	No data	Not applicable to study area	Common; primary occurrence between 100- and 4,000-m depth.	N/A

Table 3.8-3. Marine Mammals with Potential Occurrence in the Study Area (Cont'd)

Common Name	Scientific Name	Stock	Stock Abundance (CV)[4]	Study Area Abundance (CV)[4]	Occurrence	ESA/MMPA Status
		Hawaii Island	No data	Not applicable to study area	Common; primary occurrence between 100- and 4,000-m depth.	N/A
Striped dolphin[2]	*Stenella coeruleoalba*	Hawaii	20,650 (0.36)	20,650 (0.36)	Occurs regularly year-round but infrequent sighting during survey (Barlow, 2006).	N/A
Spinner dolphin Hawaiian Islands Stock Complex[2]	*Stenella longirostris longirostris*	Hawaii Pelagic	No data	No data	Common year-round in offshore waters.	N/A
		Hawaii Island	631 (0.09)	Not applicable to study area	Common year-round; rest in nearshore waters during the day and move offshore to feed at night.	N/A
		Oahu and 4-Island	355 (0.09)	Not applicable to study area	Common year-round; rest in nearshore waters during the day and move offshore to feed at night.	N/A
		Kauai and Niihau	601 (0.20)	Not applicable to study area	Common year-round; rest in nearshore waters during the day and move offshore to feed at night.	N/A
		Midway Atoll/Kure	No data	Not applicable to study area	Common year-round; rest in nearshore waters during the day and move offshore to feed at night.	N/A

Table 3.8-3. Marine Mammals with Potential Occurrence in the Study Area (Cont'd)

Common Name	Scientific Name	Stock	Stock Abundance (CV)[4]	Study Area Abundance (CV)[4]	Occurrence	ESA/MMPA Status
		Pearl and Hermes Reef	No data	Not applicable to study area	Common year-round; rest in nearshore waters during the day and move offshore to feed at night.	N/A
Rough-toothed dolphin[2]	*Steno bredanensis*	Hawaii (Hawaiian Islands EEZ)	6,288 (0.39)	6,288 (0.39)	Common throughout the Main Hawaiian Islands and Hawaii EEZ.	N/A
		Kauai/Niihau area (not a designated stock)	1,665 (0.33)	1,665 (0.33)	Common throughout the Main Hawaiian Islands and Hawaii EEZ.	N/A
		Hawaii Island (not a designated stock)	198 (0.12)	Not applicable to study area	Common throughout the Main Hawaiian Islands and Hawaii EEZ.	N/A
Fraser's dolphin[2]	*Lagenodelphis hosei*	Hawaii	16,992 (0.66)	16,992 (0.66)	Tropical species only recently documented within Hawaii EEZ (2010 survey).	N/A
Risso's dolphin[2]	*Grampus griseus*	Hawaii	7,256 (0.41)	7,256 (0.41)	Previously considered rare but multiple sightings in Hawaii EEZ during surveys conducted in 2002 and 2010.	N/A
Cuvier's beaked whale[2]	*Ziphius cavirostris*	Hawaii	1,941 (0.70)	1,941 (0.70)	Year-round occurrence but difficult to detect due to diving behavior.	N/A
Blainville's beaked whale[2]	*Mesoplodon densirostris*	Hawaii	2,338 (1.13)	2,338 (1.13)	Year-round occurrence but difficult to detect due to diving behavior.	N/A

Table 3.8-3. Marine Mammals with Potential Occurrence in the Study Area (Cont'd)

Common Name	Scientific Name	Stock	Stock Abundance (CV)[4]	Study Area Abundance (CV)[4]	Occurrence	ESA/MMPA Status
Longman's beaked whale[2]	*Indopacetus pacificus*	Hawaii	4,571 (0.65)	4,571 (0.65)	Considered rare; however, multiple sightings during 2010 survey.	N/A
Pinnipeds						
Hawaiian monk seal[2]	*Neomonachus schauinslandi*	Hawaii	1,112 (Northwestern Hawaiian Islands)	138 (Main Hawaiian Islands)	Predominantly occur at Northwestern Hawaiian Islands; approximately 138 in Main Hawaiian Islands.	Endangered/depleted

CV = coefficient of variation; EEZ = Exclusive Economic Zone; m = meters; N/A = not applicable
1. Stock designations and abundance were obtained from Muto et al., 2016.
2. Stock designations and abundance were obtained from Carretta et al., 2016.
3. Stock designations were obtained from Carretta et al., 2016 and Bradford et al., 2015; abundance was obtained from Bradford et al., 2015
4. The stated coefficient of variation (CV) is an indicator of uncertainty in the abundance estimate and describes the amount of variation with respect to the statistical population mean. It is expressed as a fraction or percentage and can range upward from zero (no uncertainty) to high values (greater uncertainty). For example, a CV of 0.8 would indicate much higher uncertainty than a CV of 0.2. When the CV reaches or exceeds 1.0, the estimate is highly uncertain, as the variation could be 100 percent or more of the estimated abundance. The uncertainty associated with movements of animals into or out of an area (due to factors such as prey availability or oceanographic conditions) is much larger than is indicated by the statistical CVs that are given.

3.8.2.1.1 Humpback Whale (*Megaptera novaeangliae*)

Status and Management

In the U.S. North Pacific Ocean, the stock structure of humpback whales is defined based on feeding areas because of the species' fidelity to feeding grounds (Carretta et al., 2016). Three stocks have been designated by NMFS in the north Pacific: (1) the Central North Pacific stock, consisting of winter and spring populations of the Hawaiian Islands that migrate to northern British Columbia and Alaska, the Gulf of Alaska, the Bering Sea, and Aleutian Islands; (2) the Western North Pacific stock, consisting of winter and spring populations off Asia that migrate to Russia and the Bering Sea and Aleutian Islands; and (3) the California/Oregon/Washington stock, consisting of animals along the U.S. west coast (Muto et al., 2016; Carretta et al., 2016).

However, in April 2015, NMFS announced a proposal to divide the species into 14 distinct population segments (DPS), including a Hawaii DPS, and to revise the listing status for the various segments (80 Federal Register [FR] 22304, April 21, 2015). A final rule on this proposal was issued on September 8, 2016 (81 FR 62260, September 8, 2016) with NMFS's determination to revise the listing status of the humpback whale under the ESA, which divides the globally listed endangered species into 14 DPSs, four of which are listed as endangered and one is listed as threatened. The Hawaii DPS (formerly known as the Central North Pacific stock) is not considered to be in danger of extinction or likely to become so in the foreseeable future. Therefore, under the final rule effective on October 11, 2016, the Hawaii DPS of humpback whales will not be listed as endangered or threatened under the ESA.

The Hawaiian Islands Humpback Whale National Marine Sanctuary, which was designated in 1992 to protect humpback whales and their habitat, is located within the HRC. The sanctuary is delineated from the shoreline to the 100-fathom (183-meter) isobath in discrete areas of the Hawaiian Islands region, including an area off the north shore of Kauai. However, the sanctuary does not coincide with the long range strike WSEP target location, which is located in waters deeper than 4,600 meters.

Geographic Range and Distribution

General. Humpback whales are distributed worldwide in all major oceans and most seas. They typically are found during the summer in high-latitude feeding grounds and during the winter in the tropics and subtropics around islands, over shallow banks, and along continental coasts, where calving occurs.

Insular Pacific-Hawaiian Large Marine Ecosystem. The Central North Pacific stock of humpback whales occurs throughout known breeding grounds in the Hawaiian Islands during winter and spring (November through April) (Muto et al., 2016). Peak occurrence is from late February through early April (Mobley et al., 2000), with a peak in acoustic detections in March (Norris et al., 1999). A recent study that also used acoustic recordings near the Northwestern Hawaiian Islands indicates that humpback whales were present from early December through early June (Lammers et al., 2011). During the fall-winter period, primary occurrence is expected from the coast to 50 NM offshore (Mobley et al., 2000; Mobley, 2004). The greatest densities of humpback whales (including calves) are in the four-island region consisting of Maui, Molokai, Kahoolawe, and Lanai, as well as Penguin Bank (Mobley et al., 2000; Maldini et al., 2005) and around Kauai (Mobley, 2005). During the spring-summer period, secondary occurrence is expected offshore out to 50 NM. Occurrence farther offshore or inshore (e.g., Pearl Harbor) has rarely been documented.

Survey results suggest that humpbacks may also be wintering in the Northwestern Hawaiian Island region and not just using it as a migratory corridor. A recent study that also used acoustic recordings near the Northwestern Hawaiian Islands indicates that humpback whales were present from early December through early June (Lammers et al., 2011). It is not yet known if this represents a previously undocumented breeding stock or if the whales occurring at the Northwestern Hawaiian Islands are part of the same population that winters near the Main Hawaiian Islands.

In breeding grounds, females with calves occur in significantly shallower waters than other groups of whales, and breeding adults use deeper, more offshore waters (Smultea, 1994; Ersts and Rosenbaum, 2003). The habitat requirements of wintering humpbacks appear to be controlled by the conditions necessary for calving, such as warm water (75 to 80 °F [24 to 28 °C]) and relatively shallow, low-relief ocean bottom in protected areas, created by islands or reefs (Smultea, 1994; Clapham, 2000; Craig and Herman, 2000).

Open ocean. Most humpback whale sightings are in nearshore and continental shelf waters; however, humpback whales frequently travel through deep oceanic waters during migration (Calambokidis et al., 2001; Clapham and Mattila, 1990; Clapham, 2000). Humpback migrations are complex and cover long distances (Calambokidis, 2009; Barlow et al., 2011). Each year, most humpback whales migrate from high-latitude summer feeding grounds to low-latitude winter breeding grounds, one of the longest migrations known for any mammal; individuals can travel nearly 4,970 miles (7,998.4 kilometers) from feeding to breeding areas (Clapham and Mead, 1999). Humpback whales that breed in Hawaii generally migrate to northern British Columbia and southeast Alaska to feed. Animals breeding in Hawaii have also been "matched" (identified as the same individual) to humpbacks feeding in southern British Columbia and northern Washington (where matches were also found to animals breeding in Central America). Hawaii humpbacks are also known to feed in the Gulf of Alaska, the Aleutian Islands, and Bering Sea where, surprisingly, matches were also found to animals that breed near islands off Mexico (Forestell and Urban-Ramirez, 2007; Barlow et al., 2011; Lagerquist et al., 2008) and between Japan and Hawaii (Salden et al., 1999). This study indicates that humpback whales migrating between Hawaii and British Columbia/southeast Alaska must cross paths with humpback whales migrating between the Gulf of Alaska/Aleutian Islands/Bering Sea and islands off Mexico. In addition, based on the identification of individual whales, there is evidence that some humpback whales (most likely males) move between winter breeding areas in Hawaii and Mexico (Forestall and Urban-Ramirez, 2007) and Hawaii and Japan (Salden et al., 1999).

Satellite tagging of humpback whales in the Hawaiian Islands found that one adult traveled 155 miles (249.4 kilometers) to Oahu, Hawaii, in 4 days, while a different individual traveled to Penguin Bank and 5 islands, totaling 530 miles (852.9 kilometers) in 10 days. Both of these trips imply faster travel between the islands than had been previously recorded (Mate et al., 1998). Three whales traveled independent courses, following north and northeast headings toward the Gulf of Alaska, with the fastest averaging 93 miles (150 kilometers) per day. At this rate, the animal would take an estimated 39 days to travel the entire 2,600-mile (4,200-kilometer) migration route to the upper Gulf of Alaska (Mate et al., 1998).

Population and Abundance

The overall abundance of humpback whales in the north Pacific was recently estimated at 21,808 individuals (coefficient of variation [CV] = 0.04; this is an indicator of statistical uncertainty and is described in a footnote in Table 3.8-2 (Occurrence of Marine Mammal Species with Multiple Designated Stocks), confirming that this population of humpback whales has continued to increase and is now greater than some pre-whaling abundance estimates (Barlow et al., 2011). Data indicate the north Pacific population has been increasing at a rate of between 5.5 percent and 6.0 percent per year, so approximately doubling every 10 years (Calambokidis et al., 2008). The Central North Pacific stock has been estimated at 10,103 individuals (CV was not calculated for this estimate) on wintering grounds throughout the Main Hawaiian Islands (Muto et al., 2016). The Hawaiian Islands Humpback Whale National Marine Sanctuary reported in 2010 that over 50 percent of the entire North Pacific humpback whale population migrates to Hawaiian waters each year (NOAA, 2010). Based on aerial surveys conducted around the Main Hawaiian Islands, the number of humpback whales was estimated at 4,491 (Mobley et al., 2001a).

Predator/Prey Interactions

The most common invertebrate prey are krill (tiny crustaceans); the most common fish prey are herring, mackerel, sand lance, sardines, anchovies, and capelin (Clapham and Mead, 1999). Feeding occurs both at the surface and in deeper waters, wherever prey is abundant. Humpback whales are the only species of baleen whale that show strong evidence of cooperation when they feed in large groups (D'Vincent et al., 1985). It is believed that minimal feeding occurs in wintering grounds, such as the Hawaiian Islands (Balcomb, 1987; Salden, 1989). This species is known to be attacked by both killer whales and false killer whales, as evidenced by tooth rake scars on their bodies and fins (Jefferson et al., 2015).

Species-Specific Threats

Entanglement in fishing gear poses a threat to individual humpback whales throughout the Pacific. Humpback whales from the Central North Pacific stock have been reported seriously injured and killed from entanglement in fishing gear while in their Alaskan feeding grounds (Muto et al., 2016). From 2009 to 2013, an average of 2.6 Central North Pacific humpback whales per year were seriously injured or killed due to entanglements with commercial fishing gear in Alaskan waters. This number is considered a minimum, since observers have not been assigned to several fisheries known to interact with this stock and quantitative data on Canadian fishery entanglements are uncertain (Muto et al., 2016). In the Hawaiian Islands, there are also reports of humpback whale entanglements with fishing gear. Since 2002, the Hawaiian Islands Disentanglement Network responded to 139 confirmed large whale entanglement reports (Hawaiian Islands Humpback Whale National Marine Sanctuary, 2014). All but three of the reports (a sei whale and two sperm whales) involved humpback whales. In the 2013–2014 season, at least 13 whales were reported as entangled, with fishing gear (crab trap and longline gear) confirmed in three of the events.

Humpback whales, especially calves and juveniles, are highly vulnerable to ship strikes. Younger whales spend more time at the surface, are less visible, and are found closer to shore (Herman et al., 1980; Mobley et al., 1999), thereby making them more susceptible to collisions. In Alaskan feeding grounds, eight ship strikes were implicated in mortality or serious injuries of humpback whales between 2003 and 2007 and seven between 2006 and 2010 (Allen and Angliss, 2011; 2013); when they migrate to and from Alaska, some of these whales spend time in Hawaii. The mean annual mortality and serious injury rate due to ship strikes reported in Hawaii between 2008 and 2012 is 2.4 humpback whales (Muto et al. 2016).

In the Hawaiian Islands, there were nine reported ship collisions with humpback whales in 2006 (none involved Navy vessels), as recorded by the NMFS Pacific Islands Region Marine Mammal Response Network Activity Updates (NMFS, 2007a). The number of confirmed ship strike reports was greater in 2007–2008; there were 12 reported ship strikes with humpback whales: 9 reported as hit by vessels and 3 observed with wounds indicating a recent ship strike (NMFS, 2008). A humpback carcass was discovered on the shore of west Molokai in 2010 with indications that the death resulted from trauma consistent with a ship strike (NMFS, 2010a).

Humpback whales are potentially affected by loss of habitat, loss of prey, underwater noise, and pollutants. The Central North Pacific stock of humpback whales is the focus of whale-watching activities in both its feeding grounds (Alaska) and breeding grounds (Hawaii). Regulations addressing minimum approach distances and vessel operating procedures are in place to help protect the whales; however, there is still concern that whales may abandon preferred habitats if the disturbance is too high (Muto et al. 2016).

3.8.2.1.2 Blue Whale (*Balaenoptera musculus*)

The world's population of blue whales can be separated into three subspecies, based on geographic location and some morphological differences. The true blue whales have been divided into two subspecies found in the northern hemisphere (*Balaenoptera musculus musculus*) and the southern hemisphere (*Balaenoptera musculus intermedia*). The third subspecies, the pygmy blue whale (*Balaenoptera musculus brevicauda*), is known to have overlapping ranges with both subspecies of true blue whales (Best et al., 2003; Reeves et al., 2002).

Status and Management

The blue whale is listed as endangered under the ESA and as depleted under the MMPA. For the MMPA Stock Assessment Reports (SARs), the Central North Pacific stock of blue whales includes animals found around the Hawaiian Islands during winter (Carretta et al., 2016).

Geographic Range and Distribution

General. The blue whale inhabits all oceans and typically occurs near the coast, over the continental shelf, though it is also found in oceanic waters. Their range includes the California Current and Insular Pacific-Hawaiian Large Marine Ecosystems and the open ocean. Blue whales have been sighted, acoustically recorded, and satellite tagged in the eastern tropical Pacific (Ferguson, 2005; Stafford et al., 2004).

Insular Pacific-Hawaiian Large Marine Ecosystem. Blue whales are found seasonally in the Hawaii region, but sighting frequency is low. Whales feeding along the Aleutian Islands of Alaska likely migrate to offshore waters north of Hawaii in winter.

Open ocean. Most blue whale sightings are in nearshore and continental shelf waters; however, blue whales frequently travel through deep oceanic waters during migration (Širović et al., 2004). Most baleen whales spend their summers feeding in productive waters near the higher latitudes and winters in the warmer waters at lower latitudes (Širović et al., 2004). Blue whales belonging to the western Pacific stock may feed in summer, south of the Aleutians and in the Gulf of Alaska, and migrate to wintering grounds in lower latitudes in the western Pacific and central Pacific, including Hawaii (Stafford et al., 2004, Watkins et al., 2000).

Population and Abundance

In the north Pacific, up to five distinct populations of blue whales are believed to occur, although only one stock is currently identified. The overall abundance of blue whales in the eastern tropical Pacific is estimated at 1,400 individuals. The most recent survey data indicate a summer/fall abundance estimate of 81 individuals (CV = 1.14) in the Hawaiian Islands EEZ (Carretta et al., 2016). This estimate could potentially be low, as the majority of blue whales would be expected to be at higher-latitude feeding grounds at that time.

Predator/Prey Interactions

This species preys almost exclusively on various types of zooplankton, especially krill. Blue whales lunge feed and consume approximately 6 tons (5,500 kg) of krill per day (Jefferson et al., 2015; Pitman et al., 2007). They sometimes feed at depths greater than 330 feet (100 meters), where their prey maintains dense groupings (Acevedo-Gutiérrez et al., 2002). Killer whales have been documented to prey on blue whales (Jefferson et al., 2015; Pitman et al., 2007). There is little evidence that killer whales attack this species in the north Atlantic or southern hemisphere, but 25 percent of photo-identified whales in the Gulf of California carry rake scars from killer whale attacks (Sears and Perrin, 2008).

Species-Specific Threats

Blue whales are considered to be susceptible to entanglement in fishing gear and ship strikes.

3.8.2.1.3 Fin Whale (*Balaenoptera physalus*)

Status and Management

The fin whale is listed as endangered under the ESA and as depleted under the MMPA. Pacific fin whale population structure is not well known. In the north Pacific, recognized stocks include the California/Oregon/Washington, Hawaii, and Northeast Pacific stocks (Carretta et al., 2016).

Geographic Range and Distribution

General. The fin whale is found in all the world's oceans and is the second largest species of whale (Jefferson et al., 2015). Fin whales prefer temperate and polar waters and are scarcely seen in warm, tropical waters (Reeves et al., 2002). Fin whales typically congregate in areas of high productivity. They spend most of their time in coastal and shelf waters but can often be found in waters of approximately 6,562 feet (2,000 meters) (Aissi et al., 2008; Reeves et al., 2002). Attracted for feeding, fin whales are often seen closer to shore after periodic patterns of upwelling and the resultant increased krill density (Azzellino et al., 2008). This species of whale is not known to have a specific habitat and is highly adaptable, following prey, typically off the continental shelf (Azzellino et al., 2008; Panigada et al., 2008). The range of the fin whale is known to include the Insular Pacific-Hawaiian Large Marine Ecosystem and the open ocean.

Insular Pacific-Hawaiian Large Marine Ecosystem. Fin whales are found in Hawaiian waters, but this species is considered to be rare in this area (Carretta et al., 2016; Shallenberger, 1981). There are known sightings from Kauai and Oahu and a single stranding record from Maui (Mobley et al., 1996; Shallenberger, 1981; DoN, 2011). Summer/fall shipboard surveys of the Hawaiian Islands EEZ resulted in five sightings in 2002 and two sightings in 2010 (Barlow, 2003; Bradford et al., 2013). A single sighting was made during aerial surveys from 1993 to 1998 (Mobley et al., 1996; Mobley et al., 2000). The most recent sighting was a single juvenile fin whale reported off Kauai in 2011 (DoN, 2011). Based on sighting data and acoustic recordings, fin whales are likely to occur in Hawaiian waters mainly in fall and winter (Barlow et al., 2006, Barlow et al., 2008, Barlow et al., 2004).

Open ocean. Fin whales have been recorded in the eastern tropical Pacific (Ferguson, 2005) and are frequently sighted there during offshore ship surveys. Fin whales are relatively abundant in north Pacific offshore waters, including areas off Hawaii (Berzin and Vladimirov, 1981; Mizroch et al., 2009). Locations of breeding and calving grounds for the fin whale are unknown, but it is known that the whales typically migrate seasonally to higher latitudes every year to feed and migrate to lower latitudes to breed (Kjeld et al., 2006; MacLeod et al., 2006a). The fin whale's ability to adapt to areas of high productivity controls migratory patterns (Canese et al., 2006; Reeves et al., 2002). Fin whales are among the fastest cetaceans, capable of attaining speeds of 25 miles (40.2 kilometers) per hour (Jefferson et al., 2015).

Population and Abundance

The current best available abundance estimate for the Hawaii stock of fin whales is 58 (CV = 1.12) (Carretta et al. 2016). This could possibly be considered an underestimate because the majority of blue whales would be expected to be at higher latitude feeding grounds at that time (Carretta et al., 2016).

Predator/Prey Interactions

This species preys on small invertebrates such as copepods, squid, and schooling fishes such as capelin, herring, and mackerel (Goldbogen et al., 2006; Jefferson et al., 2015). The fin whale is not known to have a significant number of predators. However, in regions where killer whales are abundant, some fin whales exhibit attack scars on their flippers, flukes, and flanks, suggesting possible predation by killer whales (Aguilar, 2008).

Species-Specific Threats

Fin whales are susceptible to ship strikes and entanglement in fishing gear.

3.8.2.1.4 Sei Whale (*Balaenoptera borealis*)

The sei whale is a medium-sized rorqual falling in size between fin whale and Bryde's whale and, given the difficulty of some field identifications and similarities in the general appearance of the three species, may sometimes be recorded in surveys as "unidentified rorqual."

Status and Management

The sei whale is listed as endangered under the ESA and as depleted under the MMPA. A recovery plan for the sei whale was completed in 2011 and provides a research strategy for obtaining data required to estimate population abundance and trends and to identify factors that may be limiting the recovery of this species (NMFS, 2011a). Although the International Whaling Commission recognizes one stock of sei whales in the north Pacific, some evidence indicates that more than one population exists. For the MMPA SARs, sei whales in the Pacific EEZ are divided into three areas: Hawaii, California/Oregon/Washington, and Alaska (Carretta et al., 2016).

Geographic Range and Distribution

General. Sei whales have a worldwide distribution and are found primarily in cold temperate to subpolar latitudes. During the winter, sei whales are found from 20° North [N] to 23° N and during the summer from 35° N to 50° N (Horwood, 2009; Masaki, 1976, 1977; Smultea et al., 2010). However, a recent survey of the Northern Mariana Islands recorded sei whales south of 20° N in the winter (Fulling et al., 2011). They are considered absent or at very low densities in most equatorial areas.

Insular Pacific-Hawaiian Large Marine Ecosystem. The first verified sei whale sighting made nearshore of the Main Hawaiian Islands occurred in 2007 (Smultea et al., 2007; Smultea et al., 2010) and included the first subadults seen in the Main Hawaiian Islands. A line-transect survey conducted in February 2009 by the Cetacean Research Program surrounding the Hawaiian Islands resulted in the sighting of three Bryde's/sei whales. An additional sighting occurred in 2010 of Perret Seamount (DoN, 2011). In March 2011 off Maui, the Hawaiian Islands Entanglement Response Network found a subadult sei whale entangled in rope and fishing gear (NMFS, 2011b). An attempt to disentangle the whale was unsuccessful, although a telemetry buoy attached to the entangled gear was reported to be tracking the whale over 21 days as it moved north and over 250 NM from the Hawaiian Islands.

The sei whale has been considered rare in the Hawaii region based on reported sighting data and the species' preference for cool, temperate waters. Sei whales were not sighted during aerial surveys conducted within 25 NM of the Main Hawaiian Islands from 1993 to 1998 (Mobley et al., 2000). Based on sightings made during the NMFS-Southwest Fisheries Science Center shipboard survey assessment of Hawaiian cetaceans (Barlow et al., 2004), sei whales were expected to occur in deep waters on the north side of the islands only. However, in 2007 two sei whale sightings occurred north of Oahu, Hawaii, during a short survey in November and these included three subadult whales. These latter sightings suggest that the area north of the Main Hawaiian Islands may be part of a reproductive area for north Pacific sei whales (Smultea et al., 2010). Summer/fall shipboard surveys of the Hawaiian Islands EEZ resulted in four sightings in 2002 and three in 2010 (Barlow, 2003; Bradford et al., 2013).

Open ocean. Sei whales are most often found in deep oceanic waters of the cool temperate zone. They appear to prefer regions of steep bathymetric relief, such as the continental shelf break, canyons, or basins between banks and ledges (Best and Lockyer, 2002; Gregr and Trites, 2001; Kenney and Winn, 1987; Schilling et al., 1992). On feeding grounds, the distribution is largely associated with oceanic frontal systems (Horwood, 1987). Characteristics of preferred breeding grounds are unknown, since they have generally not been identified.

Sei whales spend the summer feeding in high-latitude subpolar latitudes and return to lower latitudes to calve in winter. Whaling data provide some evidence of differential migration patterns by reproductive class, with females arriving at and departing from feeding areas earlier than males (Horwood, 1987, Perry et al., 1999). Sei whales are known to swim at speeds greater than 15 miles (25 kilometers) per hour and may be the second fastest cetacean, after the fin whale (Horwood, 2009; Jefferson et al., 2015).

Population and Abundance

The best current estimate of abundance for the Hawaii stock of sei whales is 178 animals (CV = 0.90) (Carretta et al., 2016). This abundance estimate is considered the best available estimate for the Hawaiian Islands EEZ but may be an underestimate, as sei whales are expected to be mostly at higher latitudes on their feeding grounds during this time of year (Carretta et al., 2016). No data are available on current population trends.

Predator/Prey Interactions

In the north Pacific, sei whales feed on a diversity of prey, including copepods, krill, fish (specifically sardines and anchovies), and cephalopods (squids, cuttlefish, octopuses) (Horwood, 2009; Nemoto and Kawamura, 1977). Feeding occurs primarily around dawn, which appears to be correlated with vertical migrations of prey species (Horwood, 2009). Unlike other rorquals, the sei whale skims to obtain its food, although, like other rorqual species, it does some lunging and gulping (Horwood, 2009).

Sei whales, like other large baleen whales, are likely subject to occasional attacks by killer whales.

Species-Specific Threats

Based on the statistics for other large whales, it is likely that ship strikes also pose a threat to sei whales.

3.8.2.1.5 Bryde's Whale (*Balaenoptera brydei/edeni*)

Bryde's whales are among the least known of the large baleen whales. Their classification and true number remain uncertain (Alves et al., 2010). Until recently, all medium-sized baleen whales were considered members of one of two species, Bryde's whale or sei whale. However, at least three genetically distinct types of these whales are now known, including the so-called pygmy or dwarf Bryde's whales (*Balaenoptera brydei*) (Kato and Perrin, 2008; Rice, 1998). The International Whaling

Commission continues to use the name *Balaenoptera edeni* for all Bryde's-like whales, although at least two species are recognized. In 2003, a new species (Omura's whale, *Balaenoptera omurai*) was described, and it became evident that the term "pygmy Bryde's whale" had been mistakenly used for specimens of *Balaenoptera omurai* (Reeves et al., 2004). Omura's whale is not currently known to occur in the study area and appears to be restricted to the western Pacific and Indian oceans (Jefferson et al., 2015); therefore, is not described or evaluated in this document.

Status and Management

This species is protected under the MMPA and is not listed under the ESA. The International Whaling Commission recognizes three management stocks of Bryde's whales in the north Pacific: Western North Pacific, Eastern North Pacific, and East China Sea (Donovan, 1991), although there currently is no biological basis for defining separate stocks of Bryde's whales in the central north Pacific (Carretta et al., 2016). For MMPA stock assessment reports, Bryde's whales within the Pacific U.S. EEZ are divided into two areas: Hawaii and eastern Pacific (Carretta et al., 2016).

Geographic Range and Distribution

Insular Pacific-Hawaiian Large Marine Ecosystem. Bryde's whales are only occasionally sighted in the Insular Pacific-Hawaiian Large Marine Ecosystem (Jefferson et al., 2015; Smultea et al., 2008). The first verified Bryde's whale sighting made nearshore of the Main Hawaiian Islands occurred in 2007 (Smultea et al., 2008, 2010). A line-transect survey conducted in February 2009 by the Cetacean Research Program surrounding the Hawaiian Islands resulted in the sighting of three Bryde's/sei whales (Oleson and Hill, 2009). Summer/fall shipboard surveys of waters within the Hawaiian Islands EEZ in 2002 and 2010 resulted in 13 and 30 Bryde's whale sightings, respectively (Barlow, 2003; Bradford et al., 2013). Sightings are more frequent in the northwest Hawaiian Islands than in the Main Hawaiian Islands (Barlow et al., 2004; Smultea et al., 2008; Smultea et al., 2010).

Open ocean. Bryde's whales occur primarily in offshore oceanic waters of the north Pacific. Data suggest that winter and summer grounds partially overlap in the central north Pacific (Kishiro, 1996; Ohizumi et al., 2002). Bryde's whales are distributed in the central north Pacific in summer; the southernmost summer distribution of Bryde's whales inhabiting the central north Pacific is about 20° N (Kishiro, 1996). Some whales remain in higher latitudes (around 25° N) in both winter and summer but are not likely to move poleward of 40° N (Jefferson et al., 2015; Kishiro, 1996). In some areas of the world, Bryde's whales are sometimes seen very close to shore and even inside enclosed bays (Baker and Madon, 2007; Best et al., 1984).

Long migrations are not typical of Bryde's whales, although limited shifts in distribution toward and away from the equator, in winter and summer, have been observed (Best, 1996; Cummings, 1985). They have been recorded swimming at speeds of 15 miles (24.1 kilometers) per hour (Jefferson et al., 2015; Kato and Perrin, 2008).

Population and Abundance

Little is known of population status and trends for most Bryde's whale populations. Current genetic research confirms that gene flow among Bryde's whale populations is low and suggests that management actions treat each as a distinct entity to ensure proper conservation of biological diversity (Kanda et al., 2007). A 2010 shipboard line-transect survey of the entire Hawaiian Islands EEZ yielded an abundance estimate of 798 Bryde's whales (CV = 0.28) (Bradford et al., 2013), which is the best available abundance estimate for the Hawaiian stock (Carretta et al., 2016).

Predator/Prey Interactions

Bryde's whales primarily feed on schooling fish and are lunge feeders. Prey includes anchovy, sardine, mackerel, herring, krill, and other invertebrates such as pelagic red crab (Baker and Madon, 2007; Jefferson et al., 2015; Nemoto and Kawamura, 1977). Bryde's whales have been observed using "bubble nets" to herd prey (Jefferson et al., 2015; Kato and Perrin, 2008). Bubble nets are used in a feeding strategy where the whales dive and release bubbles of air that float up in a column and trap prey inside where they lunge through the column to feed. Bryde's whale is known to be prey for killer whales, as evidenced by an aerial observation of 15 killer whales attacking a Bryde's whale in the Gulf of California (Weller, 2008).

Species-Specific Threats

Serious injury or mortality from interactions with fishing gear poses a threat to Bryde's whales.

3.8.2.1.6 Minke Whale (Balaenoptera acutorostrata)

Until recently, all minke whales were classified as the same species. However, the taxonomy is currently complex, as NMFS recognizes two species: northern or common minke whale (*Balaenoptera acutorostrata*) and Antarctic minke whale (*Balaenoptera bonaerensis*) (NOAA, 2014). The dwarf minke whale form (*Balaenoptera acutorostrata* subspecies, no official scientific name) is a possible third species, and there are several other subspecies as well. The northern minke whale is divided into two subspecies, *Balaenoptera acutorostrata scammoni* in the north Pacific and *Balaenoptera acutorostrata acutorostrata* in the north Atlantic. Accordingly, only *Balaenoptera acutorostrata scammoni* occurs in the study area.

Status and Management

The minke whale is protected under the MMPA and is not listed under the ESA. For MMPA stock assessment reports, minke whales within the Pacific U.S. EEZ are divided into three stocks: a Hawaii stock, a California/Oregon/Washington stock, and an Alaskan stock (Carretta et al., 2016). Only the Hawaii stock occurs in the study area.

Geographic Range and Distribution

General. The minke whale range is known to include the California Current and Insular Pacific-Hawaiian Large Marine Ecosystems, North Pacific Gyre, and the North Pacific Transition Zone (Okamura et al., 2001; Yamada, 1997). The northern boundary of their range is within subarctic and arctic waters (Kuker et al., 2005).

Insular Pacific-Hawaiian Large Marine Ecosystem. Minke whales previously were considered a rare species in Hawaiian waters due to limited sightings during surveys. The first documented sighting of a minke whale close to the Main Hawaiian Islands was made off the southwest coast of Kauai in 2005 (Norris et al., 2005; Rankin et al., 2007). However, recent research suggests minke whales are somewhat common in Hawaii (Rankin et al., 2007; DoN, 2011). Whales found in the Hawaii region are known to belong to seasonally migrating populations that feed in higher latitudes (Barlow, 2006). During a survey around the Hawaiian Islands, minke whales were identified as the source of the mysterious "boing" sound of the North Pacific Ocean, specifically offshore of Kauai and closer in, near the PMRF, Barking Sands region (Barlow et al., 2004; Rankin and Barlow, 2005). This new information has allowed acoustical detection of minke whales, although they are rarely observed during visual surveys (Barlow, 2006; Barlow et al., 2004; Rankin et al., 2007). Recent research using a survey vessel's towed acoustic array and the Navy's hydrophones off Kauai in 2009–2010 (35 days total) provided bearings to 1,975 minke whale "boing" vocalizations located within the instrumented range offshore of the PMRF (DoN, 2011).

Open ocean. These whales generally participate in annual migrations between low-latitude breeding grounds in the winter and high-latitude feeding grounds in the summer (Kuker et al., 2005). Minke whales generally occupy waters over the continental shelf, including inshore bays, and even occasionally enter estuaries. However, records from whaling catches and research surveys worldwide indicate an open ocean component to the minke whale's habitat. The migration paths of the minke whale include travel between breeding to feeding grounds and have been shown to follow patterns of prey availability (Jefferson et al., 2015).

Population and Abundance

There currently is no population estimate for the Hawaii stock of minke whale, which appears to occur seasonally (about October to April) around the Hawaiian Islands (Carretta et al., 2016). During summer/fall shipboard surveys of the Hawaiian Islands EEZ in 2002 and 2010 (Barlow, 2003; Bradford et al., 2013), one individual was sighted in each year. However, the majority of individuals would typically be expected to be located further north at this time of year.

Predator/Prey Interactions

This species preys on small invertebrates and schooling fish, such as sand eel, pollock, herring, and cod. Similar to other rorquals, minke whales are lunge feeders, often plunging through patches of shoaling fish or krill (Hoelzel et al., 1989; Jefferson et al., 2015). In the north Pacific, major foods include small invertebrates, krill, capelin, herring, pollock, haddock, and other small shoaling fish (Jefferson et al., 2015; Kuker et al., 2005; Lindstrom and Haug, 2001). Minke whales are prey for killer whales (Ford et al., 2005); a minke was observed being attacked by killer whales near British Columbia (Weller, 2008).

Species-Specific Threats

Serious injury or mortality from interactions with fishing gear poses a threat to minke whales.

3.8.2.1.7 Sperm Whale (*Physeter macrocephalus*)

The sperm whale is the only large whale that is an odontocete (toothed whale).

Status and Management

The sperm whale has been listed as endangered since 1970 under the precursor to the ESA and is depleted under the MMPA. Sperm whales are divided into three stocks in the Pacific. Of these, the Hawaii stock occurs within the study area.

Geographic Range and Distribution

General. The sperm whale occurs in all oceans, ranging from the pack ice in both hemispheres to the equator. Primarily, this species is typically found in the temperate and tropical waters of the Pacific (Rice, 1989). This species appears to have a preference for deep waters (Jefferson et al., 2015). Typically, sperm whale concentrations correlate with areas of high productivity, including areas near drop-offs and with strong currents and steep topography (Gannier and Praca, 2007; Jefferson et al., 2015).

Insular Pacific-Hawaiian Large Marine Ecosystem. Sperm whales occur in Hawaii waters and are one of the more abundant large whales found in that region (Baird et al., 2003a; Mobley et al., 2000).

Open ocean. Sperm whales show a strong preference for deep waters (Rice, 1989; Whitehead, 2003). Their distribution is typically associated with waters over the continental shelf break, over the continental slope, and into deeper waters.

Sperm whales are somewhat migratory. General shifts occur during summer months for feeding and breeding, while in some tropical areas, sperm whales appear to be largely resident (Rice, 1989; Whitehead, 2003; Whitehead et al., 2008). Pods of females with calves remain on breeding grounds throughout the year, between 40° N and 45° N (Rice, 1989; Whitehead, 2003), while males migrate between low-latitude breeding areas and higher-latitude feeding grounds (Pierce et al., 2007). In the northern hemisphere, "bachelor" groups (males typically 15 to 21 years old and bulls [males] not taking part in reproduction) generally leave warm waters at the beginning of summer and migrate to feeding grounds that may extend as far north as the perimeter of the arctic zone. In fall and winter, most return south, although some may remain in the colder northern waters during most of the year (Pierce et al., 2007).

Population and Abundance

The abundance of sperm whales in the eastern tropical Pacific has been estimated as 22,700 individuals. However, it is not known whether any of these animals routinely enter the Hawaiian Islands EEZ. The current best available abundance estimate for the Hawaii stock of sperm whales is 3,354 (CV = 0.34) (Carretta et al., 2016) and is based on 2010 shipboard line-transect surveys of the Hawaiian Islands EEZ (Bradford et al., 2013). Sperm whales are frequently identified via visual observation and hydrophones on the PMRF range (DoN, 2015a).

Predator/Prey Interactions

Sperm whales are known to occur in groups for both predator defense and foraging purposes. Sperm whales feed on squid, other cephalopods, and bottom-dwelling fish and invertebrates (Davis et al., 2007; Marcoux et al., 2007; Rice, 1989). Exactly how sperm whales search for, detect, and capture their prey remains uncertain. False killer whales, pilot whales, and killer whales have been documented harassing and, on occasion, attacking sperm whales (Baird, 2009a).

Species-Specific Threats

Sperm whales are susceptible to entanglement in fishing gear, ingestion of marine debris, and ship strikes.

3.8.2.1.8 Pygmy Sperm Whale (*Kogia breviceps*)

There are two species of *Kogia*: the pygmy sperm whale (*Kogia breviceps*) and the dwarf sperm whale (*Kogia sima*). Before 1966 they were considered to be the same species until morphological distinction was shown (Handley, 1966). Dwarf and pygmy sperm whales are difficult to distinguish from one another at sea, and many misidentifications have been made. Sightings of either species are often categorized as the genus *Kogia* (Jefferson et al., 2015).

Status and Management

The pygmy sperm whale is protected under the MMPA but is not listed under the ESA. Two stocks are identified in the Pacific Ocean. Of these, only the Hawaii stock occurs in the study area.

Geographic Range and Distribution

General. Pygmy sperm whales apparently occur close to shore, sometimes over the outer continental shelf. However, several studies have suggested that this species generally occurs beyond the continental shelf edge (Bloodworth and Odell, 2008; MacLeod et al., 2004). The pygmy sperm whale frequents more temperate habitats than the other *Kogia* species, which is more of a tropical species.

Insular Pacific-Hawaiian Large Marine Ecosystem. Sightings of pygmy sperm whales are rarely reported in Hawaii. During boat surveys between 2000 and 2003 in the Main Hawaiian Islands, this species was observed but less commonly than the dwarf sperm whale (Baird, 2005; Baird et al., 2003a; Barlow et al., 2004). A freshly dead specimen was observed about 100 NM north of French Frigate Shoals during a 2010 survey. Pygmy sperm whales are one of the more commonly stranded species in the Hawaiian Islands, and this frequency of strandings indicates that the species is likely more common than sightings suggest (Maldini et al., 2005).

Open ocean. Although deep oceanic waters may be the primary habitat for pygmy sperm whales, very few oceanic sightings offshore have been recorded within the study area. However, this may be because of the difficulty of detecting and identifying these animals at sea (Caldwell and Caldwell, 1989; Maldini et al., 2005). Records of this species from both the western (Japan) and eastern Pacific (California) suggest that the range of this species includes the North Pacific Central Gyre and North Pacific Transition Zone (Jefferson et al., 2015; Katsumata et al., 2004; Marten, 2000; Norman et al., 2004). Their range generally includes tropical and temperate warm water zones and is not likely to extend north into subarctic waters (Bloodworth and Odell, 2008; Jefferson et al., 2015).

Little is known about possible migrations of this species. No specific information regarding routes, seasons, or resighting rates in specific areas is available.

Population and Abundance

Few abundance estimates have been made for this species. Previously, based on results of a 2002 shipboard line-transect survey of the entire Hawaiian Islands EEZ, abundance was estimated as 7,138 individuals. However, NMFS no longer considers this information valid because it is out of date. There is no abundance estimate currently available (Carretta et al., 2016). The frequency of strandings suggests pygmy sperm whales may not be as uncommon as sightings would suggest (Jefferson et al., 2015; Maldini et al., 2005).

Predator/Prey Interactions

Pygmy sperm whales feed on cephalopods and, less often, on deep-sea fishes and shrimps (Beatson, 2007; Caldwell and Caldwell, 1989). A recent study in Hawaiian waters showed cephalopods were the primary prey of pygmy sperm whales, making up 78.7 percent of prey abundance and 93.4 percent contribution by mass (West et al., 2009). Stomach samples revealed an extreme diversity of cephalopod prey, with 38 species from 17 different families (West et al., 2009). Pygmy sperm whales have not been documented to be prey to any other species although, similar to other whale species, they are likely subject to occasional killer whale predation.

Species-Specific Threats

Pygmy sperm whales are susceptible to fisheries interactions.

3.8.2.1.9 Dwarf Sperm Whale (*Kogia sima*)

There are two species of *Kogia*, the pygmy sperm whale and the dwarf sperm whale, which had been considered to be the same species until recently. Genetic evidence suggests that there might also be two separate species of dwarf sperm whales globally, one in the Atlantic and one in the Indo-Pacific (Jefferson et al., 2015). Dwarf and pygmy sperm whales are difficult to distinguish from one another at sea, and many misidentifications have been made. Sightings of either species are often categorized as the genus *Kogia* (Jefferson et al., 2015).

Status and Management

The dwarf sperm whale is protected under the MMPA and is not listed under the ESA. NMFS has designated two stocks of dwarf sperm whales in the Pacific Ocean. Of these, the Hawaii stock occurs in the study area.

Geographic Range and Distribution

General. Dwarf sperm whales tend to occur over the outer continental shelf, and they may be relatively coastal in some areas with deep waters nearshore (MacLeod et al., 2004). Although the dwarf sperm whale appears to prefer more tropical waters than the pygmy sperm whale, the exact habitat preferences of the species are not well understood. Dwarf sperm whales have been observed in both outer continental shelf and more oceanic waters. Records of this species from both the western Pacific (Taiwan) and eastern Pacific (California) suggest that its range includes the southern portions of the California Current Large Marine Ecosystem, all waters of the North Pacific Central Gyre, the Insular Pacific-Hawaiian Large Marine Ecosystem, and the southern portion of the North Pacific Transition Zone (Jefferson et al., 2015; Wang and Yang, 2006; Wang et al., 2001).

Insular Pacific-Hawaiian Large Marine Ecosystem. During vessel surveys between 2000 and 2003 in the Main Hawaiian Islands, this species was the sixth most commonly observed species, typically in deep water (to 10,400 feet [3,169.9 meters]) (Baird, 2005; Baird et al., 2003a; Barlow et al., 2004). Small boat surveys within the Main Hawaiian Islands since 2002 have documented dwarf sperm whales on

73 occasions, most commonly in water depths between 500 meters and 1,000 meters (Baird et al., 2013). Dwarf sperm whales are one of the more commonly stranded species in the Hawaiian Islands (Maldini et al., 2005), and the frequency of strandings indicates that the species is likely more common than sightings suggest.

Open ocean. Although deep oceanic waters may be the primary habitat for this species, very few oceanic sightings offshore have occurred within the study area. The lack of sightings may be due to the difficulty of detecting and identifying these animals at sea (Jefferson et al., 2015; Maldini et al., 2005).

Population and Abundance

Results of a 2002 shipboard line-transect survey of the entire Hawaiian Islands EEZ indicated an abundance of 17,519 individuals. However, NMFS considers this information to be out of date and no longer valid. Accordingly, there is no current abundance estimate available for this stock (Carretta et al., 2016). The frequency of strandings suggests that dwarf sperm whales may not be as uncommon as sightings would suggest (Jefferson et al., 2015).

Predator/Prey Interactions

Dwarf sperm whales feed on cephalopods and, less often, on deep sea fishes and shrimps (Caldwell and Caldwell, 1989; Sekiguchi et al., 1992). Dwarf sperm whales generally forage near the seafloor (McAlpine, 2009). Killer whales are predators of dwarf sperm whales (Dunphy-Daly et al., 2008).

Species-Specific Threats

There are no significant species-specific threats to dwarf sperm whales in the study area.

3.8.2.1.10 Killer Whale (*Orcinus orca*)

A single species of killer whale is currently recognized, but genetic and morphological evidence has led some cetacean biologists to consider the possibility of multiple species or subspecies worldwide. In the north Pacific, these forms are variously known as ‘‘residents,’’ ‘‘transients,” and “offshore” ecotypes (Hoelzel et al., 2007).

Status and Management

The killer whale is protected under the MMPA, and overall the species is not listed under the ESA (the southern resident population in Puget Sound, not found in the study area, is listed as endangered under the ESA and depleted under the MMPA). The AT1 transient stock is also depleted under the MMPA. In the Pacific Ocean, NMFS recognizes the AT1 transient stock, five Eastern North Pacific stocks, Gulf of Alaska, Aleutian Islands, and Bering Sea transient stock, and a Hawaii stock. Only the Hawaii stock occurs in the study area.

Geographic Range and Distribution

General. Killer whales are found in all marine habitats from the coastal zone (including most bays and inshore channels) to deep oceanic basins and from equatorial regions to the polar pack ice zones of both hemispheres. Although killer whales are also found in tropical waters and the open ocean, they are most numerous in coastal waters and at higher latitudes (Dahlheim and Heyning, 1999). The range of this species is known to include the Insular Pacific-Hawaiian Large Marine Ecosystem, the North Pacific Gyre, and North Pacific Transition Zone.

Insular Pacific-Hawaiian Large Marine Ecosystem. Although killer whales apparently prefer cooler waters, they have been observed in Hawaiian waters (Barlow, 2006; Shallenberger, 1981). Sightings are extremely infrequent in Hawaiian waters, and typically occur during winter, suggesting those sighted are seasonal migrants (Baird et al., 2003b; Mobley et al., 2001b). Baird (2006) documented 21 sightings of killer whales within the Hawaiian Islands EEZ, primarily around the Main Hawaiian Islands. Summer/fall surveys of the Hawaiian Islands EEZ resulted in one sighting (Bradford et al., 2013). Killer whales are occasionally sighted off Kauai (e.g., Cascadia Research, 2012a). There are also documented strandings in the Hawaiian Islands for this species (Maldini et al., 2005).

Open ocean. This species is known to occur in deep oceanic waters off Hawaii and elsewhere in the Pacific (Carretta et al., 2016; Miyashita et al., 1996; Wang et al., 2001). In the eastern tropical Pacific, killer whales are known to occur in waters from offshore of San Diego to Hawaii and south to Peru (Barlow, 2006; Ferguson, 2005). Offshore killer whales are known to inhabit both the western and eastern temperate Pacific and likely have a continuous distribution across the north Pacific (Steiger et al., 2008).

In most areas of their range, killer whales do not show movement patterns that would be classified as traditional migrations. However, there are often seasonal shifts in density, both onshore/offshore and north/south.

Population and Abundance

The current best available abundance estimate for the Hawaii stock, based on a 2010 shipboard survey of the entire Hawaiian Islands EEZ, is 101 (CV = 1.00) killer whales (Carretta et al., 2016).

Predator/Prey Interactions

Killer whales feed on a variety of prey, including bony fishes, elasmobranchs (a class of fish composed of sharks, skates, and rays), cephalopods, seabirds, sea turtles, and other marine mammals (Fertl et al., 1996; Jefferson et al., 2015). Some populations are known to specialize in specific types of prey (Jefferson et al., 2015; Krahn et al., 2004; Wade et al., 2009). The killer whale has no known natural predators; it is considered to be the top predator of the oceans (Ford, 2008).

Species-Specific Threats

Boat traffic has been shown to affect the behavior of the endangered southern resident killer whale population around San Juan Island, Washington (Lusseau et al., 2009). In the presence of boats, whales were significantly less likely to be foraging and significantly more likely to be traveling (Lusseau et al., 2009). These changes in behavior were particularly evident when boats were within 330 feet (100 meters) of the whales. While this population of killer whales is not present in the study area, their behavior may be indicative of other killer whale populations that are present.

Another issue has been recognized as a potential threat to the endangered southern resident killer whale population: the potential reduction in prey, particularly Chinook salmon (Ford et al., 2009). As noted above, while this population of killer whales is not present in the study area, prey reduction may be a threat to other killer whale populations as well.

Additionally, killer whales may be particularly susceptible to interactions with fisheries, including entanglement.

3.8.2.1.11 False Killer Whale (*Pseudorca crassidens*)

Status and Management

Not much is known about most false killer whale populations globally, but the species is known to be present in Hawaiian waters. NMFS currently recognizes a Hawaiian Islands Stock Complex, which includes the Hawaii pelagic stock, the Northwestern Hawaiian Islands stock, and the Main Hawaiian Islands insular stock. All stocks of false killer whale are protected under the MMPA. The Main Hawaiian Islands insular stock (considered resident to the Main Hawaiian Islands consisting of Kauai, Oahu, Molokai, Lanai, Kahoolawe, Maui, and Hawaii) is listed as endangered under the ESA and as depleted under the MMPA. The historical decline of this stock has been the result of various non-Navy factors that include the small population size of this stock, evidence of decline of the local Hawaii stock, and incidental take by commercial fisheries (Oleson et al., 2010). It is estimated that approximately eight false killer whales from the Main Hawaiian Islands Insular and Hawaii Pelagic stocks are killed or seriously injured by commercial longline fisheries each year (McCracken and Forney, 2010). This number is most likely an underestimate, since it does not include any animals that were unidentified and might have been false killer whales. Due to evidence of a serious decline in the population (Reeves et al., 2009), a Take Reduction Team (a team of experts to study the specific topic, also referred to as a Biological Reduction Team) was formed by the NOAA in 2010 as required by the MMPA. As a result of the Take Reduction Team's activities, a Take Reduction Plan was published in 2012. The plan identifies regulatory and nonregulatory measures designed to reduce mortalities and serious injuries of false killer whales that are associated with Hawaii longline fisheries.

The NMFS considers all false killer whales found within 72 kilometers (39 NM) of each of the Main Hawaiian Islands as part of the Main Hawaiian Islands insular stock. In the vicinity of the Main Hawaiian Islands, the pelagic stock is considered to inhabit waters greater than 11 kilometers (6 NM) from shore. There is no inner boundary for the pelagic stock within the Northwestern Hawaiian Islands. Animals belonging to the Northwestern Hawaiian Islands stock are considered to inhabit waters within a 93-kilometer (50-NM) radius of the Northwestern Hawaiian Islands, or the boundary of the Papahānaumokuākea Marine National Monument, with the radial boundary extended to the southeast to encompass Kauai and Niihau. NMFS recognizes that there is geographic overlap between the stocks in some areas. All three stocks have potential for occurrence at the Long Range Strike WSEP impact location. This overlap precludes analysis of differential impact between the stocks based on spatial criteria.

The density data used in the Navy's modeling and analyses were derived from habitat-based density models for the combined stocks, since limited sighting data did not allow for stock-specific models (Becker et al., 2012). Habitat-based density models allow predictions of cetacean densities on a finer spatial scale than traditional analyses (Barlow et al., 2009) and, thus, are better suited for spatially explicit effects analyses. In the most recent SAR (Carretta et al., 2016), separate abundance numbers are provided for each stock of the false killer whale Hawaiian Islands Stock Complex.

Geographic Range and Distribution

General. The range of this species is known to include waters of the Insular Pacific-Hawaiian Large Marine Ecosystem and the North Pacific Gyre.

Insular Pacific-Hawaiian Large Marine Ecosystem. The false killer whale is regularly found within Hawaiian waters and has been reported in groups of up to 100 (Shallenberger, 1981; Baird et al., 2003b). A handful of stranding records exists in the Hawaiian Islands (Maldini et al., 2005). Distribution of Main Hawaiian Islands insular false killer whales has been assessed using data from visual surveys and satellite tag data. Tagging data from seven groups of individuals tagged off the islands of Hawaii and Oahu indicate that the whales move rapidly and semi-regularly throughout the Main Hawaiian Islands and have been documented as far as 112 kilometers offshore over a total range of 31,969 square miles (82,800 square kilometers) (Baird et al., 2012). Baird et al. (2012) note, however, that limitations in the sampling "suggest the range of the population is likely underestimated, and there are probably other high-use areas that have not been identified." Photo-identification studies also document that the animals regularly use both leeward and windward sides of the islands (Baird et al., 2005a; Baird, 2009a; Baird et al., 2010a; Forney et al., 2010; Baird et al., 2012). Some individual false killer whales tagged off the Island of Hawaii have remained around that island for extended periods (days to weeks), but individuals from all tagged groups eventually were found broadly distributed throughout the Main Hawaiian Islands (Baird, 2009a; Forney et al., 2010). Individuals utilize habitat over varying water depths from less than 164 feet (50 meters) to greater than 13,123 feet (4,000 meters) (Baird et al., 2010a). It has been hypothesized that inter-island movements may depend on the density and movement patterns of their prey species (Baird, 2009a).

Open ocean. In the north Pacific, this species is known to occur in deep oceanic waters off Hawaii and elsewhere in the Pacific (Carretta et al., 2016; Miyashita et al., 1996; Wang et al., 2001). False killer whales are not considered a migratory species, although seasonal shifts in density likely occur. Seasonal movements in the western north Pacific may be related to prey distribution (Odell and McClune, 1999). Satellite-tracked individuals around the Hawaiian islands indicate that false killer whales can move extensively among different islands and also sometimes move from an island coast to as far as 60 miles (96.6 kilometers) offshore (Baird, 2009a; Baird et al., 2010a).

Population and Abundance

False killer whales found in waters surrounding the Main Hawaiian Islands are known to be genetically separate from the population in the outer part of the Hawaiian Islands EEZ and the central tropical Pacific (Chivers et al., 2007; Reeves et al., 2009). Recent genetic research by Chivers et al. (2010) indicates that the Main Hawaiian Islands insular and Hawaii pelagic populations of false killer whales are independent and do not interbreed. The current abundance estimate of the Main Hawaiian Islands insular stock is 151 individuals (CV = 0.20), the Hawaii pelagic stock is 1,540 individuals (CV = 0.66), and the Northwestern Hawaiian Islands stock is 617 individuals (CV = 1.11) (Carretta et al., 2016).

Reeves et al. (2009) summarized information on false killer whale sightings near Hawaii between 1989 and 2007, based on various survey methods, and suggested that the Main Hawaiian Islands stock may have declined during the last two decades. Baird (2009a) reviewed trends in sighting rates of false killer whales from aerial surveys conducted using consistent methodology around the Main Hawaiian Islands between 1994 and 2003. Sighting rates during these surveys exhibited a significant decline that could not be attributed to any weather or methodological changes. Data are currently insufficient to determine population trends for the Northwestern Hawaiian Islands or Hawaii Pelagic stocks (Carretta et al., 2016).

Predator/Prey Interactions

False killer whales feed primarily on deep-sea cephalopods and fish (Odell and McClune, 1999). They may prefer large fish species, such as mahi mahi and tunas. Twenty-five false killer whales that stranded off the coast of the Strait of Magellan were examined and found to feed primarily on cephalopods and fish. Squid beaks were found in nearly half of the stranded animals. The most important prey species were found to be the squid species *Martialiabyadesi* and *Illex argentinus,* followed by the coastal fish *Macruronus magellanicus* (Alonso et al., 1999). False killer whales have been observed to attack other cetaceans, including dolphins and large whales such as humpback and sperm whales (Baird, 2009b). They are known to behave aggressively toward small cetaceans in tuna purse seine nets. Unlike other whales or dolphins, false killer whales frequently pass prey back and forth among individuals before they start to eat the fish, in what appears to be a way of affirming social bonds (Baird et al., 2010a). This species is believed to be preyed on by large sharks and killer whales (Baird, 2009b). Like many marine mammals, false killer whales accumulate high levels of toxins in their blubber over the course of their long lives. Because they feed on large prey at the top of the food chain (e.g., squid, tunas) they may be impacted by competition with fisheries (Cascadia Research, 2010).

Species-Specific Threats

In Hawaiian waters, false killer whales are particularly susceptible to fishery interactions and entanglements (Forney et al., 2010).

3.8.2.1.12 Pygmy Killer Whale (*Feresa attenuata*)

The pygmy killer whale is often confused with the false killer whale and melon-headed whale, which are similar in overall appearance.

Status and Management

The pygmy killer whale is protected under the MMPA and is not listed under the ESA. For the MMPA stock assessment reports, there is a single Pacific management stock, including animals found within the Hawaiian Islands EEZ and in adjacent high seas waters. However, due to lack of data regarding abundance, distribution, and impacts for high-seas waters, the status of the stock is evaluated based only on occurrence in waters of the Hawaiian Islands EEZ.

Geographic Range and Distribution

General. The pygmy killer whale is generally an open-ocean, deepwater species (Davis et al., 2000; Wursig et al., 2000).

Insular Pacific-Hawaiian Large Marine Ecosystem. Although rarely seen in nearshore waters, sightings have been relatively frequent in the Insular Pacific-Hawaiian Large Marine Ecosystem (Barlow et al., 2004; Donahue and Perryman, 2008; Pryor et al., 1965; Shallenberger, 1981; Smultea et al., 2007). A line-transect survey conducted in February 2009 by the Cetacean Research Program surrounding the Hawaiian Islands resulted in the sighting of one pygmy killer whale (Oleson and Hill, 2009). Shipboard surveys in the Hawaiian Islands EEZ in 2002 and 2010 resulted in a total of eight additional sightings (Barlow, 2006; Bradford et al., 2013). Six strandings have been documented from Maui and the Island of Hawaii (Carretta et al., 2010; Maldini et al., 2005).

Open ocean. This species' range in the open ocean generally extends to the southern regions of the North Pacific Gyre and the southern portions of the North Pacific Transition Zone. Many sightings have occurred from cetacean surveys of the eastern tropical Pacific (Au and Perryman, 1985; Barlow and Gisiner, 2006; Wade and Gerrodette, 1993). This species is also known to be present in the western Pacific (Wang and Yang, 2006). Its range is generally considered to be south of 40° N and continuous across the Pacific (Donahue and Perryman, 2008; Jefferson et al., 2015). Migrations or seasonal movements are not known.

Population and Abundance

Although the pygmy killer whale has an extensive global distribution, it is not known to occur in high densities in any region and, thus, is probably one of the least abundant of the pantropical delphinids. The current best available abundance estimate for the pygmy killer whale derives from a 2010 shipboard survey of the Hawaiian Islands EEZ (Bradford et al., 2013); the estimate was 3,433 individuals (CV = 0.52) (Carretta et al., 2016).

Predator/Prey Interactions

Pygmy killer whales feed predominantly on fish and squid. They have been known to attack other dolphin species, apparently as prey, although this is not common (Jefferson et al., 2015; Perryman and Foster, 1980; Ross and Leatherwood, 1994). The pygmy killer whale has no documented predators (Weller, 2008). However, like other cetaceans, it may be subject to predation by killer whales.

Species-Specific Threats

Fisheries interactions are likely as evidenced by a pygmy killer whale that stranded on Oahu with signs of hooking injury (NMFS, 2007a) and the report of mouthline injuries noted in some individuals (Baird unpublished data cited in Carretta et al., 2011). It has been suggested that pygmy killer whales may be particularly susceptible to loud underwater sounds, such as active sonar and seismic operations, based on the stranding of pygmy killer whales in Taiwan (Wang and Yang, 2006). However, this suggestion is probably not supported by the data available.

3.8.2.1.13 Short-Finned Pilot Whale (*Globicephala macrorhynchus*)

Status and Management

Short-finned pilot whales are protected under the MMPA and are not listed under the ESA. For MMPA stock assessment reports, short-finned pilot whales within the Pacific U.S. EEZ are divided into two discrete areas: (1) waters off California, Oregon, and Washington and (2) Hawaiian waters. The short-finned pilot whale is widely distributed throughout most tropical and warm temperate waters of the world.

Geographic Range and Distribution

General. A number of studies in different regions suggest that the distribution and seasonal inshore/offshore movements of pilot whales coincide closely with the abundance of squid, their preferred prey (Bernard and Reilly, 1999; Hui, 1985; Payne and Heinemann, 1993). This species' range generally extends to the southern regions of the North Pacific Gyre and the California Current and Insular Pacific-Hawaiian Large Marine Ecosystems. Many sightings have occurred from cetacean surveys of the eastern tropical Pacific, where the species is reasonably common (Au and Perryman, 1985; Barlow, 2006; Wade and Gerrodette, 1993).

Insular Pacific-Hawaiian Large Marine Ecosystem. Short-finned pilot whales are known to occur in waters surrounding the Hawaiian Islands (Barlow, 2006; Shallenberger, 1981; Smultea et al., 2007). They are most commonly observed around the Main Hawaiian Islands, are relatively abundant around Oahu and the Island of Hawaii, and are also present around the Northwestern Hawaiian Islands (Barlow, 2006; Maldini Feinholz, 2003; Shallenberger, 1981). Fourteen strandings of this species have been recorded at the Main Hawaiian Islands, including five mass strandings (Carretta et al., 2016; Maldini et al., 2005). Short-finned pilot whales were detected in nearshore waters off the western shore of Kauai during passive acoustic and visual surveys in 2014.

Open ocean. The short-finned pilot whale occurs mainly in deep offshore areas; thus, the species occupies waters over the continental shelf break, in slope waters, and in areas of high topographic relief (Olson, 2009). While pilot whales are typically distributed along the continental shelf break, movements over the continental shelf are commonly observed in the northeastern United States (Payne and Heinemann, 1993) and close to shore at oceanic islands, where the shelf is narrow and deeper waters are found nearby (Gannier, 2000; Mignucci-Giannoni, 1998). Short-finned pilot whales are not considered a migratory species, although seasonal shifts in abundance have been noted in some portions of the species' range.

Population and Abundance

A 2010 shipboard survey of the entire Hawaiian Islands EEZ resulted in an abundance estimate of 12,422 (CV = 0.43) short-finned pilot whales and is considered to be the best available estimate (Carretta et al., 2016; Bradford et al., 2013).

Predator/Prey Interactions

Pilot whales feed primarily on squid but also take fish (Bernard and Reilly, 1999). They are generally well adapted to feeding on squid (Jefferson et al., 2015; Werth, 2006a, b). Pilot whales are not generally known to prey on other marine mammals, but records from the eastern tropical Pacific suggest that the short-finned pilot whale does occasionally chase and attack, and may eat, dolphins during fishery operations (Olson, 2009; Perryman and Foster, 1980). They have also been observed harassing sperm whales in the Gulf of Mexico (Weller et al., 1996).

This species is not known to have any predators (Weller, 2008). It may be subject to predation by killer whales.

Species-Specific Threats

Short-finned pilot whales are particularly susceptible to fisheries interactions and entanglement.

3.8.2.1.14 Melon-Headed Whale (*Peponocephala electra*)

This small tropical dolphin species is similar in appearance to the pygmy killer whale.

Status and Management

The melon-headed whale is protected under the MMPA and is not listed under the ESA. NMFS has identified a Hawaiian Islands Stock Complex, which consists of Hawaiian Islands and Kohala Resident stocks. The Kohala Resident stock includes melon-headed whales off the Kohala Peninsula and west coast of Hawaii Island, in waters less than 2,500 meters deep. These whales would not be expected in the study area. The Hawaiian Islands stock includes whales occurring throughout the Hawaiian Islands EEZ (including the area of the Kohala resident stock) and adjacent high-seas waters. Due to a lack of data, stock evaluation is based on whales in the Hawaiian Islands EEZ only. In addition, in the area of overlap between the two stocks, individual animals can currently only be distinguished by photographic identification.

Geographic Range and Distribution

General. Melon-headed whales are found worldwide in tropical and subtropical waters. They have occasionally been reported at higher latitudes, but these movements are considered to be beyond their normal range because the records indicate these movements occurred during incursions of warm water currents (Perryman et al., 1994). The range of this species is known to include waters of the Insular Pacific-Hawaiian Large Marine Ecosystem and the North Pacific Gyre (Jefferson et al., 2015; Perryman, 2008). In the north Pacific, occurrence of this species is well known in deep waters off many areas, including Hawaii (Au and Perryman, 1985; Carretta et al., 2016; Ferguson, 2005; Perrin, 1976; Wang et al., 2001).

Insular Pacific-Hawaiian Large Marine Ecosystem. The melon-headed whale is regularly found in Hawaiian waters (Baird et al., 2003a; Baird et al., 2003b; Mobley et al., 2000; Shallenberger, 1981). Large groups are seen regularly, especially off the Waianae coast of Oahu, the north Kohala coast of Hawaii, and the leeward coast of Lanai (Baird, 2006; Shallenberger, 1981). A line-transect survey conducted in February 2009 by the Cetacean Research Program surrounding the Hawaiian Islands resulted in the sighting of one melon-headed whale (Oleson and Hill, 2009). Similarly, a shipboard survey of the entire Hawaiian Islands EEZ in 2010 resulted in one sighting (Bradford et al., 2013). A total of 14 stranding records exist for this species in the Hawaiian Islands (Carretta et al., 2010; Maldini et al., 2005).

Open ocean. Melon-headed whales are most often found in offshore deep waters but sometimes move close to shore over the continental shelf. Brownell et al. (2009) found that melon-headed whales near oceanic islands rest near shore during the day and feed in deeper waters at night. The melon-headed whale is not known to migrate.

Population and Abundance

As described in the most recent stock assessment report (Carretta et al., 2016), the current best available abundance estimate for the Hawaiian Islands stock of melon-headed whale is 5,794 (CV = 0.20). The abundance estimate for the Kohala resident stock is 447 individuals (CV = 0.12).

Predator/Prey Interactions

Melon-headed whales prey on squid, pelagic fishes, and occasionally crustaceans. Most of the fish and squid families eaten by this species consist of mid-water forms found in waters as deep as 4,920 feet (1,500 meters), suggesting that feeding takes place deep in the water column (Jefferson and Barros, 1997). Melon-headed whales are believed to be preyed on by killer whales and have been observed fleeing from killer whales in Hawaiian waters (Baird et al., 2006a).

Species-Specific Threats

There are no significant species-specific threats to melon-headed whales in Hawaii, although it is likely that they are susceptible to fisheries interactions.

3.8.2.1.15 Bottlenose Dolphin (*Tursiops truncatus*)

The classification of the genus *Tursiops* continues to be in question. Two species are recognized: the common bottlenose dolphin (*Tursiops truncatus*) and the Indo-Pacific bottlenose dolphin (*Tursiops aduncus*) (Rice, 1998), though additional species are likely to be recognized with future analyses (Natoli et al., 2004).

Status and Management

The bottlenose dolphin is protected under the MMPA and is not listed under the ESA. For the MMPA stock assessment reports, multiple bottlenose dolphin stocks are designated within the Pacific U.S. EEZ. However, within the region of the study area, NMFS has identified five stocks that comprise the bottlenose dolphin Hawaiian Islands Stock Complex: (1) Hawaii Pelagic, (2) Kauai/ Niihau, (3) Oahu, (4) 4-Island, and (5) Hawaii Island. The most recent stock assessment report indicates that demographically independent populations likely exist in the Northwestern Hawaiian Islands. However, data are currently insufficient to delineate such stocks, and bottlenose dolphins in this portion of Hawaii are included in the pelagic stock.

Geographic Range and Distribution

General. Common bottlenose dolphins are found most commonly in coastal and continental shelf waters of tropical and temperate regions of the world. They occur in most enclosed or semi-enclosed seas. The species inhabits shallow, murky, estuarine waters and also deep, clear offshore waters in oceanic regions (Jefferson et al., 2015; Wells et al., 2009). Common bottlenose dolphins are often found in bays, lagoons, channels, and river mouths and are known to occur in very deep waters of some ocean regions. The range of this species is known to include waters of the Insular Pacific-Hawaiian Large Marine Ecosystem, the North Pacific Gyre, and the North Pacific Transition Zone (Au and Perryman, 1985; Carretta et al., 2016; Miyashita, 1993; Wang and Yang, 2006).

Insular Pacific-Hawaiian Large Marine Ecosystem. Common bottlenose dolphins are common throughout the Hawaiian Islands, and they are typically observed throughout the main islands and from the Island of Hawaii to Kure Atoll within 5 miles (8.05 kilometers) of the coast (Baird et al., 2009a; Shallenberger, 1981). In the Hawaiian Islands, this species is found in both shallow coastal waters and deep offshore waters (Baird et al., 2003a). The offshore variety is typically larger than the inshore. Twelve stranding records from the Main Hawaiian Islands exist (Maldini et al., 2005; Maldini Feinholz, 2003). Common bottlenose dolphin vocalizations have been documented during acoustic surveys, and the species has been commonly sighted during aerial surveys in the Hawaiian Islands (Barlow et al., 2008; Barlow et al., 2004; Mobley et al., 2000). Bottlenose dolphins were detected in nearshore waters off the western shore of Kauai during passive acoustic and visual surveys in 2014.

Open ocean. In the eastern tropical Pacific and elsewhere, open ocean populations occur far from land. However, population density appears to be higher in nearshore areas (Scott and Chivers, 1990). In the north Pacific, common bottlenose dolphins have been documented in offshore waters as far north as about 41° N (Carretta et al., 2010). Although in most areas bottlenose dolphins do not migrate (especially where they occur in bays, sounds, and estuaries), seasonal shifts in abundance do occur in many areas (Griffin and Griffin, 2004).

Population and Abundance

The current best available abundance estimate of the Hawaiian Islands Stock Complex of common bottlenose dolphins comes from a ship survey of the entire Hawaiian Islands EEZ in 2010 (Bradford et al., 2013). The resulting abundance estimates for the various stocks are as follows: (1) Hawaii Pelagic, 5,950 individuals (CV = 0.59); (2) Kauai and Niihau, 147 individuals (CV = 0.11); (3) Oahu, 594 individuals (CV = 0.54); (4) 4-Island, 153 individuals (CV = 0.24); and (5) Hawaii Island, 102 individuals (CV = 0.13) (Carretta et al., 2016).

The criteria and thresholds developed by the Navy and NMFS result in consideration of potential impacts at distances ranging from immediately adjacent to the activity (meters) to tens of kilometers from some acoustic stressors. Therefore, the abundance estimates and generalized boundaries and locations for bottlenose dolphins stocks in Hawaii are insufficient to allow for an analysis of impacts on individual stocks, and they are treated as a group and discussed in terms of the Hawaiian Islands Stock Complex.

Predator/Prey Interactions

These animals are opportunistic feeders, taking a wide variety of fishes, cephalopods, and shrimps (Wells and Scott, 1999) and using a variety of feeding strategies (Shane, 1990). In addition to using echolocation, a process for locating prey by emitting sound waves that reflect back, bottlenose dolphins likely detect and orient to fish prey by listening for the sounds their prey produce (so-called passive listening) (Barros and Myrberg, 1987; Barros and Wells, 1998). Nearshore bottlenose dolphins prey predominantly on coastal fish and cephalopods, while offshore individuals prey on open ocean cephalopods and a large variety of near-surface and mid-water fish species (Mead and Potter, 1995). Throughout its range, this species is known to be preyed on by killer whales and sharks (Wells and Scott, 2008).

Species-Specific Threats

Common bottlenose dolphins are particularly susceptible to entanglement and other interactions with fishery operations.

3.8.2.1.16 Pantropical Spotted Dolphin (*Stenella attenuata*)

Status and Management

The species is protected under the MMPA and is not listed under the ESA. For the MMPA stock assessment reports, NMFS has identified four stocks that compose the pantropical spotted dolphin Hawaiian Islands Stock Complex: (1) Hawaii Pelagic, (2) Oahu, 3) 4-Island, and (4) Hawaii Island.

Geographic Range and Distribution

General. The pantropical spotted dolphin is distributed in offshore tropical and subtropical waters of the Pacific, Atlantic, and Indian Oceans between about 40° N and 40° S (Baldwin et al., 1999; Perrin, 2008a). The species is much more abundant in the lower latitudes of its range. It is found mostly in deeper offshore waters but does approach the coast in some areas (Jefferson et al., 2015; Perrin, 2001).

Insular Pacific-Hawaiian Large Marine Ecosystem. Based on known habitat preferences and sighting data, the primary occurrence for the pantropical spotted dolphin in the Insular Pacific-Hawaiian Large Marine Ecosystem is between 330 and 13,122 feet (100.6 to 3,999.6 meters) deep. This area of primary occurrence also includes a continuous band connecting all the Main Hawaiian Islands, Nihoa, and Kaula, taking into account possible inter-island movements. Secondary occurrence is expected from the shore to 330 feet (100.6 meters), as well as seaward of 13,120 feet (3,998.9 meters). Pantropical spotted dolphins make up a relatively large portion of odontocete sightings around Oahu, the 4-Island region, and the Island of Hawaii (about one-fourth of total sightings); however, they are largely absent from nearshore waters around Kauai and Niihau (about 4 percent of sightings) (Baird et al., 2013).

Open ocean. In the open ocean, this species ranges from 25° N (Baja California, Mexico) to 17° S (southern Peru) (Perrin and Hohn, 1994). Pantropical spotted dolphins are associated with warm tropical surface water in the eastern tropical Pacific (Au and Perryman, 1985; Reilly, 1990). Au and Perryman

(1985) noted that the species occurs primarily north of the equator, off southern Mexico, and westward along 10° N.

Although pantropical spotted dolphins do not migrate, extensive movements are known in the eastern tropical Pacific (although these have not been strongly linked to seasonal changes) (Scott and Chivers, 2009).

Population and Abundance

Morphological and coloration differences and distribution patterns have been used to establish that the spotted dolphins around Hawaii belong to a stock that is distinct from those in the eastern tropical Pacific (Carretta et al., 2010). Based on shipboard surveys of the Hawaiian Islands EEZ, the current best available abundance estimate of the Hawaii Pelagic stock of the Hawaiian Islands Stock Complex is 15,917 individuals (CV = 0.40) (Carretta et al., 2016). There is currently insufficient information to provide abundance estimates for the remaining three stocks (Oahu, 4-Island Region, and Hawaii Island).

Predator/Prey Interactions

Pantropical spotted dolphins prey on near-surface fish, squid, and crustaceans and on some mid-water species (Perrin and Hohn, 1994). Results from various tracking and food habit studies suggest that pantropical spotted dolphins off Hawaii feed primarily at night on surface and mid-water species that rise with the deep scattering layer toward the water's surface after dark (Baird et al., 2001; Robertson and Chivers, 1997). Pantropical spotted dolphins may be preyed on by killer whales and sharks and have been observed fleeing killer whales in Hawaiian waters (Baird et al., 2006a). Other predators may include the pygmy killer whale, false killer whale, and occasionally the short-finned pilot whale (Perrin, 2008a).

Species-Specific Threats

Although information on fishery-related impacts to cetaceans in Hawaiian waters is limited, the gear types used in other fisheries throughout U.S. waters result in marine mammal mortality and injury, and pantropical spotted dolphins in the Hawaii region are likely impacted to some degree as well. The most recent stock assessment report describes both anecdotal and documented negative interactions with fishing activities. Pantropical spotted dolphins located in the eastern tropical Pacific have had high mortality rates associated with the tuna purse seine fishery (Wade, 1994).

3.8.2.1.17 Striped Dolphin (*Stenella coeruleoalba*)

Status and Management

This species is protected under the MMPA and is not listed under the ESA. In the western north Pacific, three migratory stocks are recognized. In the eastern Pacific, NMFS divides striped dolphin management stocks within the U.S. EEZ into two separate areas: (1) waters off California, Oregon, and Washington and (2) waters around Hawaii.

Geographic Range and Distribution

General. Although primarily a warm-water species, the range of the striped dolphin extends higher into temperate regions than those of any other species in the genus *Stenella*. Striped dolphins also are generally restricted to oceanic regions and are seen close to shore only where deep water approaches the coast. In some areas (e.g., the eastern tropical Pacific), they are mostly associated with convergence zones and regions of upwelling (Au and Perryman, 1985; Reilly, 1990). The northern limits are the Sea of Japan, Hokkaido, Washington State, and along roughly 40° N across the western and central Pacific (Reeves et al., 2002). In the eastern tropical Pacific, striped dolphins inhabit areas with large seasonal changes in surface temperature and thermocline depth, as well as seasonal upwelling (Au and Perryman, 1985; Reilly, 1990). In some areas, this species appears to avoid waters with sea temperatures less than 68 °F (20 °C) (Van Waerebeek et al., 1998).

Insular Pacific-Hawaiian Large Marine Ecosystem. The striped dolphin regularly occurs around the Insular Pacific-Hawaiian Large Marine Ecosystem, although sightings are relatively infrequent there (Carretta et al., 2016). Summer/fall shipboard surveys of the Hawaiian Islands EEZ in 2002 and 2010 resulted in 15 and 29 sightings, respectively (Barlow, 2006; Bradford et al., 2013). The species occurs primarily seaward at a depth of about 547 feet (1,000 meters), based on sighting records and the species' known preference for deep waters. Striped dolphins are occasionally sighted closer to shore in Hawaii, so an area of secondary occurrence is expected from a depth range of 55 to 547 feet (100 to 1,000 meters). Occurrence patterns are assumed to be the same throughout the year (Mobley et al., 2000).

Open ocean. The primary range of the striped dolphin includes the eastern and western waters of the North Pacific Transition Zone (Perrin et al., 1994a). The species is nonmigratory in the study area.

Population and Abundance

The best available estimate of abundance for the Hawaii stock of the striped dolphin, based on the 2010 shipboard surveys described above, is 20,650 individuals (CV = 0.36) (Carretta et al., 2016).

Predator/Prey Interactions

Striped dolphins often feed in open sea or sea-bottom zones along the continental slope or just beyond it in oceanic waters. Most of their prey possess light-emitting organs, suggesting that striped dolphins may be feeding at great depths, possibly diving to 655 to 2,295 feet (200 to 700 meters) (Archer and Perrin, 1999). Striped dolphins may feed at night in order to take advantage of the deep scattering layer's diurnal vertical movements. Small mid-water fishes (in particular lanternfishes) and squids are the predominant prey (Perrin et al., 1994a). This species has been documented to be preyed upon by sharks (Ross, 1971). It may also be subject to predation by killer whales.

Species-Specific Threats

There are no significant species-specific threats to striped dolphins in the study area.

3.8.2.1.18 Spinner Dolphin (*Stenella longirostris*)

Six morphotypes within four subspecies of spinner dolphins have been described worldwide in tropical and warm-temperate waters, including *Stenella longirostris longirostris* (Gray's, or pantropical, spinner dolphin), *Stenella longirostris orientalis* (eastern spinner dolphin), *Stenella longirostris centroamericana* (Central American spinner dolphin), and *Stenella longirostris roseiventris* (dwarf spinner dolphin) (Perrin et al., 2009). The Gray's spinner dolphin is the most widely distributed and is the subspecies that occurs in the study area. Hawaiian spinner dolphins belong to a stock that is separate from animals in the eastern tropical Pacific.

Status and Management

The spinner dolphin is protected under the MMPA, and the species is not listed under the ESA. Although the eastern spinner dolphin (*Stenella longirostris orientalis*) is listed as depleted under the MMPA, the Gray's spinner dolphin, which occurs in the study area, is not designated as depleted. NMFS has identified six stocks that compose the spinner dolphin Hawaiian Islands Stock Complex: (1) Hawaii Pelagic, (2) Hawaii Island, (3) Oahu and 4-Island, (4) Kauai and Niihau, (5) Midway Atoll/Kure, and (6) Pearl and Hermes Reef. The pelagic stock includes animals found both within the Hawaiian Islands EEZ (but outside of island-associated boundaries) and in adjacent international waters. Based on an analysis of individual spinner dolphin movements, no dolphins have been found farther than 10 NM from shore, and few individuals move long distances (from one Main Hawaiian Island to another) (Hill et al., 2011).

Geographic Range and Distribution

General. Spinner dolphins occur in both oceanic and coastal environments. Most sightings have been associated with inshore waters, islands, or banks (Perrin and Gilpatrick, 1994). Open ocean populations, such as those in the eastern tropical Pacific, often are found in waters with a shallow thermocline (rapid temperature difference with depth) (Au and Perryman, 1985; Perrin, 2008b; Reilly, 1990). The thermocline concentrates open sea organisms in and above it, which spinner dolphins feed on. In the eastern tropical Pacific, spinner dolphins are associated with tropical surface waters typified by extensive stable thermocline ridging and relatively little annual variation in surface temperature (Au and Perryman, 1985; Perrin, 2008b). Coastal populations are usually found in island archipelagos, where they are associated with coastal trophic and habitat resources (Norris and Dohl, 1980; Poole, 1995).

Insular Pacific-Hawaiian Large Marine Ecosystem. In the Hawaiian Islands, spinner dolphins occur along the leeward coasts of all the major islands and around several of the atolls northwest of the Main Hawaiian Islands. Long-term site fidelity has been noted for spinner dolphins along the Kona coast of Hawaii and along Oahu (Marten and Psarakos, 1999; Norris et al., 1994). Navy monitoring for the Rim of the Pacific Exercise in 2006 resulted in daily sightings of spinner dolphins in the offshore area of Kekaha Beach, Kauai, near the PMRF (DoN, 2006). Spinner dolphins were detected in nearshore waters off the western shore of Kauai during passive acoustic and visual surveys in 2014.

Spinner dolphins occur year-round throughout the Insular Pacific-Hawaiian Large Marine Ecosystem, with primary occurrence from the shore to the 13,122-foot (3,999.6-meter) depth. This takes into account offshore resting habitat and offshore feeding areas. Spinner dolphins are expected to occur in shallow water resting areas (about 162 feet [49.4 meters] deep or less) throughout the middle of the day, moving into deep waters offshore during the night to feed. Primary resting areas are along the west side of Hawaii, including Makako Bay, Honokohau Bay, Kailua Bay, Kealakekua Bay, Honaunau Bay, and Kauhako Bay and off Kahena on the southeast side of the island (Östman-Lind et al., 2004). Along the Waianae coast of Oahu, Hawaii, spinner dolphins rest along Makua Beach, Kahe Point, and Pokai Bay during the day (Lammers, 2004). Kilauea Bay on Kauai is also a popular resting bay for Hawaiian spinner dolphins (DoN, 2006). Another area of occurrence is seaward of 2,187 fathoms (4,000 meters). Although sightings have been recorded around the mouth of Pearl Harbor, Hawaii, spinner dolphin occurrence is rare there (Lammers, 2004). Occurrence patterns are assumed to be the same throughout the year.

Open ocean. Throughout much of their range, spinner dolphins are found in the open ocean. Spinner dolphins are pantropical, ranging through oceanic tropical and subtropical zones in both hemispheres (the range is nearly identical to that of the pantropical spotted dolphin). The primary range of Gray's spinner dolphin is known to include waters of the North Pacific Gyre and the southern waters of the North Pacific Transition Zone. Its range generally includes tropical and subtropical oceanic waters south of 40° N, continuous across the Pacific (Jefferson et al., 2015; Perrin and Gilpatrick, 1994).

Spinner dolphins are not considered a migratory species.

Population and Abundance

Hawaiian spinner dolphins belong to a separate stock than animals found in the eastern tropical Pacific. Abundance estimates are currently available for only three of the stocks composing the Hawaiian Islands Stock Complex: Hawaii Island, 790 individuals (CV = 0.17); Oahu and 4-Island, 355 individuals (CV = 0.09); and Kauai/Niihau, 601 individuals (CV = 0.20) (Carretta et al., 2016). Data are currently insufficient to calculate an abundance estimate for the remaining three stocks (Hawaii Pelagic, Midway Atoll/Kure, and Pearl and Hermes Reef).

Predator/Prey Interactions

Spinner dolphins feed primarily on small mid-water fishes, squids, and shrimp, and they dive to at least 655 to 985 feet (200 to 300 meters) (Perrin and Gilpatrick, 1994). They forage primarily at night, when the midwater community migrates toward the surface and the shore (Benoit-Bird, 2004; Benoit-Bird et al., 2001). Spinner dolphins track the horizontal migrations of their prey (Benoit-Bird and Au, 2003), allowing for foraging efficiencies (Benoit-Bird, 2004; Benoit-Bird and Au, 2003). Foraging behavior has also been linked to lunar phases in scattering layers off of Hawaii (Benoit-Bird and Au, 2004). Spinner dolphins may be preyed on by sharks, killer whales, pygmy killer whales, and short-finned pilot whales (Perrin, 2008b).

Species-Specific Threats

There are no significant species-specific threats to spinner dolphins in the study area.

3.8.2.1.19 Rough-Toothed Dolphin (*Steno bredanensis*)

Status and Management

This species is protected under the MMPA and is not listed under the ESA. Rough-toothed dolphins are among the most widely distributed species of tropical dolphins, but little information is available regarding population status (Jefferson, 2009; Jefferson et al., 2015). Genetic studies and sighting data indicate there may be at least two island-associated stocks in the Main Hawaiian Islands (Hawaii Island and Kauai/Niihau stocks). NMFS has designated two Pacific management stocks including the Hawaii stock and the American Samoa stock. The Hawaii stock includes animals found within the Hawaiian Islands EEZ and adjacent high seas waters; the American Samoa stock includes animals inhabiting the EEZ waters around American Samoa (Carretta et al., 2016). Only the Hawaii stock of rough-toothed occurs in the study area.

Geographic Range and Distribution

General. The range of this species is known to include waters of the Insular Pacific-Hawaiian Large Marine Ecosystem and the North Pacific Gyre. This species is known to prefer deep water but has been observed in waters of various depths. At the Society Islands, rough-toothed dolphins were sighted in waters with bottom depths ranging from less than 330 feet (100 meters) to more than 9,845 feet (more than 3,000 meters), although they apparently favored the 1,640- to 4,920-foot (500- to 1,500-meter) range (Gannier, 2000).

Insular Pacific-Hawaiian Large Marine Ecosystem. The occurrence of this species is well known in deep ocean waters off Hawaii (Baird et al., 2008; Barlow et al., 2008; Carretta et al., 2016; Pitman and Stinchcomb, 2002; Shallenberger, 1981). Rough-toothed dolphin vocalizations have been detected during acoustic surveys in the eastern tropical Pacific (Oswald et al., 2003). A ship survey in the Hawaiian Islands found that sighting rates were highest in depths greater than 4,920 feet (1,500 meters) and resightings were frequent, indicating the possibility of a small population with high site fidelity (Baird et al., 2008). This species has been observed as far northwest as French Frigate Shoals (Carretta et al., 2010). Eight strandings have been reported from the Hawaiian Islands of Maui, Oahu, and Hawaii (Maldini et al., 2005). Rough-toothed dolphins were detected in nearshore waters off the western shore of Kauai during passive acoustic and visual surveys in 2014.

Open ocean. The rough-toothed dolphin is regarded as an offshore species that prefers deep water, but it can occur in waters of variable bottom depth (Gannier and West, 2005). It rarely occurs close to land, except around islands with steep drop-offs near shore (Gannier and West, 2005). However, in some areas, this species may frequent coastal waters and areas with shallow bottom depths (Davis et al., 1998; Fulling et al., 2003; Lodi and Hetzel, 1999; Mignucci-Giannoni, 1998; Ritter, 2002).

There is no evidence that rough-toothed dolphins migrate. No information regarding routes, seasons, or resighting rates in specific areas is available.

Population and Abundance

Based on shipboard surveys of the Hawaiian Islands EEZ conducted in 2010 (Bradford et al., 2013), the best available abundance estimate for the Hawaii stock of rough-toothed dolphins is 6,288 individuals (CV = 0.39) (Carretta et al., 2016). Although island-specific stocks are not currently recognized by NMFS for management purposes, abundance estimates are provided in the most recent stock assessment report for Kauai/Niihau (1,665 individuals, CV = 0.33) and Hawaii Island (198 individuals, CV = 0.12) (Carretta et al., 2016). The island-specific estimates are based on photographic identification surveys conducted primarily within 40 kilometers of shore and are not considered representative of abundance within the Hawaiian Islands EEZ.

Predator/Prey Interactions

Prey of rough-toothed dolphins includes fish and cephalopods. They are known to feed on large fish species, such as mahi mahi (Miyazaki and Perrin, 1994; Pitman and Stinchcomb, 2002). They also prey on reef fish, as Perkins and Miller (1983) noted that parts of reef fish had been found in the stomachs of stranded rough-toothed dolphins in Hawaii. Gannier and West (2005) observed rough-toothed dolphins feeding during the day on near-surface fishes, including flyingfishes.

Although this species has not been documented as prey by other species, it may be subject to predation from killer whales.

Species-Specific Threats

Rough-toothed dolphins are particularly susceptible to commercial and recreational fishery interactions.

3.8.2.1.20 Fraser's Dolphin (*Lagenodelphis hosei*)

Although information on Fraser's dolphin has increased in recent years, the species is still one of the least-known cetaceans. Fraser's dolphin was discovered in 1956 and after that time was known only from skeletal remains until it was once again identified in the early 1970s (Perrin et al., 1973).

Status and Management

Fraser's dolphin is protected under the MMPA and is not listed under the ESA. For the MMPA stock assessment reports, there is a single Pacific management stock including only animals found within the Hawaiian Islands EEZ.

Geographic Range and Distribution

General. Fraser's dolphin is a tropical oceanic species, except where deep water approaches the coast (Dolar, 2008).

Insular Pacific-Hawaiian Large Marine Ecosystem. Fraser's dolphins have only recently been documented within the Insular Pacific-Hawaiian Large Marine Ecosystem. The first published sightings were during a 2002 cetacean survey (Barlow, 2006; Carretta et al., 2016), at which time the mean group size recorded was 286 (Barlow, 2006). Additional sightings were recorded during a 2010 survey (Bradford et al., 2013). There are no records of strandings of this species in the Hawaiian Islands (Maldini et al., 2005). Fraser's dolphin vocalizations have been documented in the Hawaiian Islands (Barlow et al., 2008; Barlow et al., 2004). It is not known whether Fraser's dolphins found in Hawaiian waters are part of the same population that occurs in the eastern tropical Pacific (Carretta et al., 2010).

Open ocean. In the offshore eastern tropical Pacific, this species is distributed mainly in upwelling-modified waters (Au and Perryman, 1985; Reilly, 1990). The range of this species includes deep open ocean waters of the North Pacific Gyre and the Insular Pacific-Hawaiian Large Marine Ecosystem and other locations in the Pacific (Aguayo and Sanchez, 1987; Ferguson, 2005; Miyazaki and Wada, 1978).

This does not appear to be a migratory species, and little is known about its potential migrations. No specific information regarding routes, seasons, or resighting rates in specific areas is available.

Population and Abundance

The current best available abundance estimate for the Hawaii stock of Fraser's dolphin derives from a 2010 shipboard survey of the entire Hawaiian Islands EEZ, resulting in an estimate of 16,992 (CV = 0.66) (Carretta et al. 2016; Bradford et al., 2013).

Predator/Prey Interactions

Fraser's dolphin feeds on mid-water fishes, squids, and shrimps and has not been documented to be prey to any other species (Jefferson and Leatherwood, 1994; Perrin et al., 1994b). However, it may be subject to predation by killer whales.

Species-Specific Threats

There are no significant species-specific threats to Fraser's dolphins in the study area.

3.8.2.1.21 Risso's Dolphin (*Grampus griseus*)

Status and Management

Risso's dolphin is protected under the MMPA and is not listed under the ESA. For the MMPA stock assessment reports, Risso's dolphins within the Pacific U.S. EEZ are divided into two separate areas: (1) waters off California, Oregon, and Washington and (2) Hawaiian waters (Carretta et al., 2016). The Hawaii stock includes animals found within the Hawaiian Islands EEZ and adjacent high seas waters.

Geographic Range and Distribution

General. In the Pacific, the range of this species is known to include the North Pacific Gyre and the California Current and Insular Pacific-Hawaiian Large Marine Ecosystems. Occurrence of this species is well known in deep open ocean waters off Hawaii and in other locations in the Pacific (Au and Perryman, 1985; Carretta et al., 2016; Leatherwood et al., 1980; Miyashita, 1993; Miyashita et al., 1996; Wang et al., 2001).

Insular Pacific-Hawaiian Large Marine Ecosystem. Risso's dolphins have been considered rare in Hawaiian waters (Shallenberger, 1981). However, during a 2002 survey of the Hawaiian Islands EEZ, seven sightings were reported; in addition, two sightings were reported from recent aerial surveys in the Hawaiian Islands (Barlow, 2006; Mobley et al., 2000). During a more recent 2010 systematic survey of the Hawaiian Islands EEZ, there were 12 sightings of Risso's dolphins. In 2009, Risso's dolphins were acoustically detected near Hawaii using boat-based hydrophones (DoN, 2009). In addition, Risso's dolphins were sighted eight times during Navy monitoring activities within HRC between 2005 and 2012 (HDR, 2012). Five strandings in the Main Hawaiian Islands have been recorded (Maldini et al., 2005).

Open ocean. Several studies have documented that Risso's dolphins are found offshore, along the continental slope, and over the outer continental shelf (Baumgartner, 1997; Canadas et al., 2002; Cetacean and Turtle Assessment Program, 1982; Davis et al., 1998; Green et al., 1992; Kruse et al., 1999; Mignucci-Giannoni, 1998). Risso's dolphins are also found over submarine canyons (Mussi et al., 2004).

Risso's dolphin does not migrate, although schools may range over very large distances. Seasonal shifts in centers of abundance are known for some regions.

Population and Abundance

This is a widely distributed species that occurs in all major oceans, and although no global population estimates exist, it is generally considered to be one of the most abundant of the large dolphins. The current best available abundance estimate for the Hawaiian stock of Risso's dolphin derives from a 2010 shipboard survey of the entire Hawaiian Islands EEZ (Bradford et al., 2013). The resulting abundance estimate is 7,526 individuals (CV = 0.41) (Carretta et al., 2016).

Predator/Prey Interactions

Cephalopods and crustaceans are the primary prey for Risso's dolphins (Clarke, 1996), which feed mainly at night (Baird et al., 2008; Jefferson et al., 2015). This dolphin may be preyed on by both killer whales and sharks, although there are no documented reports of predation by either species (Weller, 2008).

Species-Specific Threats

Risso's dolphins are particularly susceptible to entanglement and fisheries interactions.

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

Status and Management

Cuvier's beaked whale is protected under the MMPA and is not listed under the ESA. Cuvier's beaked whale stocks are defined for three separate areas within Pacific U.S. waters: (1) Alaska; (2) California, Oregon, and Washington; and (3) Hawaii (Carretta et al., 2016).

Geographic Range and Distribution

General. Cuvier's beaked whales have an extensive range that includes all oceans, from the tropics to the polar waters of both hemispheres. Worldwide, beaked whales normally inhabit continental slope and deep oceanic waters. Cuvier's beaked whales are generally sighted in waters with a bottom depth greater than 655 feet (199.6 meters) and are frequently recorded in waters with bottom depths greater than 3,280 feet (999.7 meters) (Falcone et al., 2009; Jefferson et al., 2015). Cuvier's beaked whale range is known to include all waters of the Insular Pacific-Hawaiian Large Marine Ecosystem, the North Pacific Gyre, and the North Pacific Transition Zone (Jefferson et al., 2015; MacLeod and D'Amico, 2006).

Insular Pacific-Hawaiian Large Marine Ecosystem. Cuvier's beaked whales are regularly found in waters surrounding the Hawaiian Islands, having been sighted from vessels and aerial surveys. A line-transect survey surrounding the Hawaiian Islands conducted in February 2009 by the Cetacean Research Program (Oleson and Hill, 2009) resulted in the sighting of two Cuvier's beaked whales, while shipboard surveys of the Hawaiian Islands EEZ in 2020 (Bradford et al., 2013) resulted in 22 sightings. They typically are found at depths exceeding 6,560 feet (2,000 meters) (Baird et al., 2009b; Baird et al., 2006b; Barlow et al., 2004). In the Hawaiian Islands, five strandings have been reported from Midway Island, Pearl and Hermes Reef, Oahu, and the Island of Hawaii (Maldini et al., 2005; Shallenberger, 1981). Sightings have been reported off the Hawaiian Islands of Lanai, Maui, Hawaii, Niihau, and Kauai, supporting the hypothesis that there is a resident population in the Hawaiian Islands (Baird et al., 2010b; Carretta et al., 2016; Mobley et al., 2000; Shallenberger, 1981).

Open ocean. Cuvier's beaked whales are widely distributed in offshore waters of all oceans and, thus, occur in temperate and tropical waters of the Pacific, including waters of the eastern tropical Pacific (Barlow et al., 2006; Ferguson, 2005; Jefferson et al., 2015; Pitman et al., 1988). In the study area, they are found mostly offshore in deeper waters off Hawaii (MacLeod and Mitchell, 2006; Mead, 1989; Ohizumi and Kishiro, 2003; Wang et al., 2001). Little is known about potential migration.

Population and Abundance

The current best available abundance estimate for the Hawaii stock is 1,941 individuals (CV = 0.70) (Carretta et al., 2016), based on a 2010 shipboard line-transect survey of the Hawaiian Islands EEZ (Bradford et al., 2013).

Predator/Prey Interactions

Cuvier's beaked whales, similar to other beaked whale species, are apparently deepwater feeders. Stomach content analyses show that they feed mostly on deep-sea squid, fish, and crustaceans (Hickmott, 2005; Santos et al., 2007). They apparently use suction to swallow prey (Jefferson et al., 2015; Werth, 2006a, b). Cuvier's beaked whales may be preyed upon by killer whales (Heyning and Mead, 2008; Jefferson et al., 2015).

Species-Specific Threats

Cuvier's beaked whales commonly strand, and they are considered vulnerable to acoustic impacts (Frantzis et al., 2002; Cox et al., 2006; Southall et al., 2012). Additionally, Cuvier's beaked whales entangled in fishing gear have been documented.

3.8.2.1.23 Blainville's Beaked Whale (*Mesoplodon densirostris*)

Status and Management

Due to difficulty in distinguishing the different *Mesoplodon* species from one another, the U.S. management unit is usually defined to include all *Mesoplodon* species that occur in an area. Blainville's beaked whale is protected under the MMPA and is not listed under the ESA. Although little is known of stock structure for this species, based on resightings and genetic analysis of individuals around the Hawaiian Islands, NMFS recognizes a Hawaii stock of Blainville's beaked whale.

Geographic Range and Distribution

General. Blainville's beaked whales are one of the most widely distributed of the distinctive toothed whales within the *Mesoplodon* genus (Jefferson et al., 2015; MacLeod and Mitchell, 2006). Blainville's beaked whale range is known to include the Insular Pacific-Hawaiian Large Marine Ecosystem, North Pacific Gyre, and the North Pacific Transition Zone (Jefferson et al., 2015; Pitman, 2008).

Insular Pacific-Hawaiian Large Marine Ecosystem. Blainville's beaked whales are regularly found in Hawaiian waters (Baird et al., 2003a; Baird et al., 2006b; Barlow et al., 2004). In Hawaiian waters, this species is typically found in areas where water depths exceed 3,280 feet (1,000 meters) along the continental slope (Barlow et al., 2006; Baird et al., 2010a). Blainville's beaked whale has been detected off the coast of Oahu, Hawaii, for prolonged periods annually, and this species is consistently observed in the same site off the west coast of the Island of Hawaii (McSweeney et al. 2007). Blainville's beaked whales' vocalizations have been detected on acoustic surveys in the Hawaiian Islands, and stranding records are available for the region (Maldini et al., 2005; Rankin and Barlow, 2007). A recent tagging study conducted off the Island of Hawaii found the movements of a Blainville's beaked whale to be restricted to the waters of the west and north side of the island (Baird et al., 2010b). Blainville's beaked whales were detected in nearshore waters off the western shore of Kauai during passive acoustic and visual surveys in 2014.

Open ocean. Blainville's beaked whales are found mostly offshore in deeper waters along the California coast, Hawaii, Fiji, Japan, and Taiwan, as well as throughout the eastern tropical Pacific (Leslie et al., 2005; MacLeod and Mitchell, 2006; Mead, 1989). It is unknown whether this species makes specific migrations, and none have so far been documented. Populations studied in Hawaii have evidenced some level of residency (McSweeney et al., 2007).

Population and Abundance

The best available abundance estimate for Blainville's beaked whale Hawaii stock is based on a 2010 shipboard line-transect survey of the entire Hawaiian Islands U.S. EEZ (Bradford et al., 2013). The resulting estimate is 2,338 individuals (CV = 1.13) (Carretta et al., 2016).

Predator/Prey Interactions

This species preys on squid and possibly deepwater fish. Like other *Mesoplodon* species, Blainville's beaked whales apparently use suction for feeding (Jefferson et al., 2015; Werth, 2006a; Werth, 2006b). This species has not been documented as prey for any other species although, like other cetaceans, it is likely subject to occasional killer whale predation.

Species-Specific Threats

Blainville's beaked whales have been shown to react to anthropogenic noise by avoidance (Tyack et al., 2011). In response to a simulated sonar signal and pseudorandom noise (a signal of pulsed sounds that are generated in a random pattern), a tagged whale ceased foraging at depth and slowly moved away from the source while gradually ascending toward the surface (Tyack et al., 2011).

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

Status and Management

Longman's beaked whale is protected under the MMPA and is not listed under the ESA. Longman's beaked whale is a rare beaked whale species and is considered one of the world's least-known cetaceans (Dalebout et al., 2003; Pitman, 2008). Only one Pacific stock, the Hawaii stock, is identified (Carretta et al., 2016).

Geographic Range and Distribution

General. Longman's beaked whales generally are found in warm tropical waters, with most sightings occurring in waters with sea surface temperatures warmer than 78 °F (26 °C) (Anderson et al., 2006; MacLeod and D'Amico, 2006; MacLeod et al., 2006). Sighting records of this species in the Indian Ocean showed Longman's beaked whale is typically found over deep slopes 655 to more than 6,560 feet (200 to more than 2,000 meters) (Anderson et al., 2006).

Although the full extent of this species distribution is not fully understood, there have been many recorded sightings at various locations in tropical waters of the Pacific and Indian Oceans (Afsal et al., 2009; Dalebout et al., 2002; Dalebout et al., 2003; Moore, 1972). Ferguson et al. (2001) reported that all Longman's beaked whale sightings were south of 25° N.

Records of this species indicate presence in the eastern, central, and western Pacific. The range of Longman's beaked whale generally includes the Insular Pacific-Hawaiian Large Marine Ecosystem and the North Pacific Gyre (Gallo-Reynoso and Figueroa-Carranza, 1995; Jefferson et al., 2015; MacLeod and D'Amico, 2006).

Insular Pacific-Hawaiian Large Marine Ecosystem. Sighting records for this species indicate presence in waters to the west of the Hawaiian Islands (four Longman's beaked whales were observed during the 2002 Hawaiian Islands Cetacean and Ecosystem Assessment, also known as the HICEAS survey [Barlow et al., 2004]) and to the northwest of the Hawaiian archipelago (23°42'38" N and 176°33'78" W). During a more recent 2010 HICEAS survey, there were multiple sightings of Longman's beaked whale. Longman's beaked whales have also been sighted off Kona (Cascadia Research, 2012b). Shipboard surveys of the Hawaiian Islands EEZ in 2010 resulted in three sightings (Bradford et al., 2013). There are two known records of this species stranding in the Hawaiian Islands (Maldini et al., 2005; West et al., 2012).

Open ocean. Worldwide, Longman's beaked whales normally inhabit continental slope and deep oceanic waters (greater than 655 feet [200 meters]) and are only occasionally reported in waters over the continental shelf (Canadas et al., 2002; Ferguson et al., 2006; MacLeod et al., 2006b; Pitman, 2008; Waring et al., 2001).

Little information regarding the migration of this species is available, but it is considered to be widely distributed across the tropical Pacific and Indian Oceans (Jefferson et al., 2015). It is unknown whether the Longman's beaked whale participates in a seasonal migration (Jefferson et al., 2015; Pitman, 2008).

Population and Abundance

Based on 2010 surveys of the Hawaiian Islands EEZ (Bradford et al., 2013), the best available abundance estimate of the Hawaii stock is 4,571 individuals (CV = 0.65) (Carretta et al., 2016).

Predator/Prey Interactions

Based on recent tagging data from Cuvier's and Blainville's beaked whales, Baird et al. (2005b) suggested that feeding for Longman's beaked whale might occur at mid-water rather than only at or near the bottom (Heyning, 1989; MacLeod et al., 2003). This species has not been documented as prey for any other species, though it is likely subject to occasional killer whale predation.

Species-Specific Threats

Little information exists regarding species-specific threats to Longman's beaked whales in the study area. However, recently the first case of morbillivirus in the central Pacific was documented for a stranded juvenile male Longman's beaked whale at Hamoa beach, Hana, Maui (West et al., 2012).

3.8.2.1.25 Hawaiian Monk Seal (*Neomonachus schauinslandi*)

Status and Management

The Hawaiian monk seal was listed as endangered under the ESA in 1976 and is listed as depleted under the MMPA. The species is considered a high priority for recovery, based on the high magnitude of threats, high recovery potential, and potential for economic conflicts while implementing recovery actions (NMFS, 2007b). Hawaiian monk seals are managed as a single stock. NMFS has identified reproductive subpopulations at French Frigate Shoals, Laysan Island, Lisianski Island, Pearl and Hermes Reef, Midway Atoll, Kure Atoll, and Necker and Nihoa Islands in the Northwestern Hawaiian Islands (NMFS, 2014). The species also occurs throughout the Main Hawaiian Islands. There is a population of approximately 200 individuals in the Main Hawaiian Islands (NMFS, 2016), and the total population is estimated to be fewer than 1,200 individuals. The approximate area encompassed by the Northwestern Hawaiian Islands was designated as the Papahanaumokuakea National Marine Monument in 2006.

A recovery plan for the Hawaiian monk seal was completed in 1983 and was revised in 2007 (NMFS, 2007b). In 1986, critical habitat was designated for all beach areas, sand spits and islets, lagoon waters, inner reef waters, and ocean waters to a depth of 10 fathoms (18.3 meters) around Kure Atoll, Midway Islands (except Sand Island), Pearl and Hermes Reef, Lisianski Island, Laysan Island, Gardner Pinnacles, French Frigate Shoals, Necker Island, and Nihoa Island in the Northwestern Hawaiian Islands (NMFS, 1986). In 1988, the critical habitat was extended to include Maro Reef and waters around previously recommended areas out to the 20-fathom (36.6-meter) isobath (NMFS, 1988). In order to reduce the probability of direct interaction between Hawaiian-based longline fisheries and monk seals, a protected species zone was put into place in the Northwestern Hawaiian Islands, prohibiting longline fishing in this zone. In 2000, the waters from 3 to 50 NM around the Northwestern Hawaiian Islands were designated the Northwestern Hawaiian Islands Coral Reef Ecosystem Reserve, and specific restrictions were placed on human activities there (Antonelis et al., 2006).

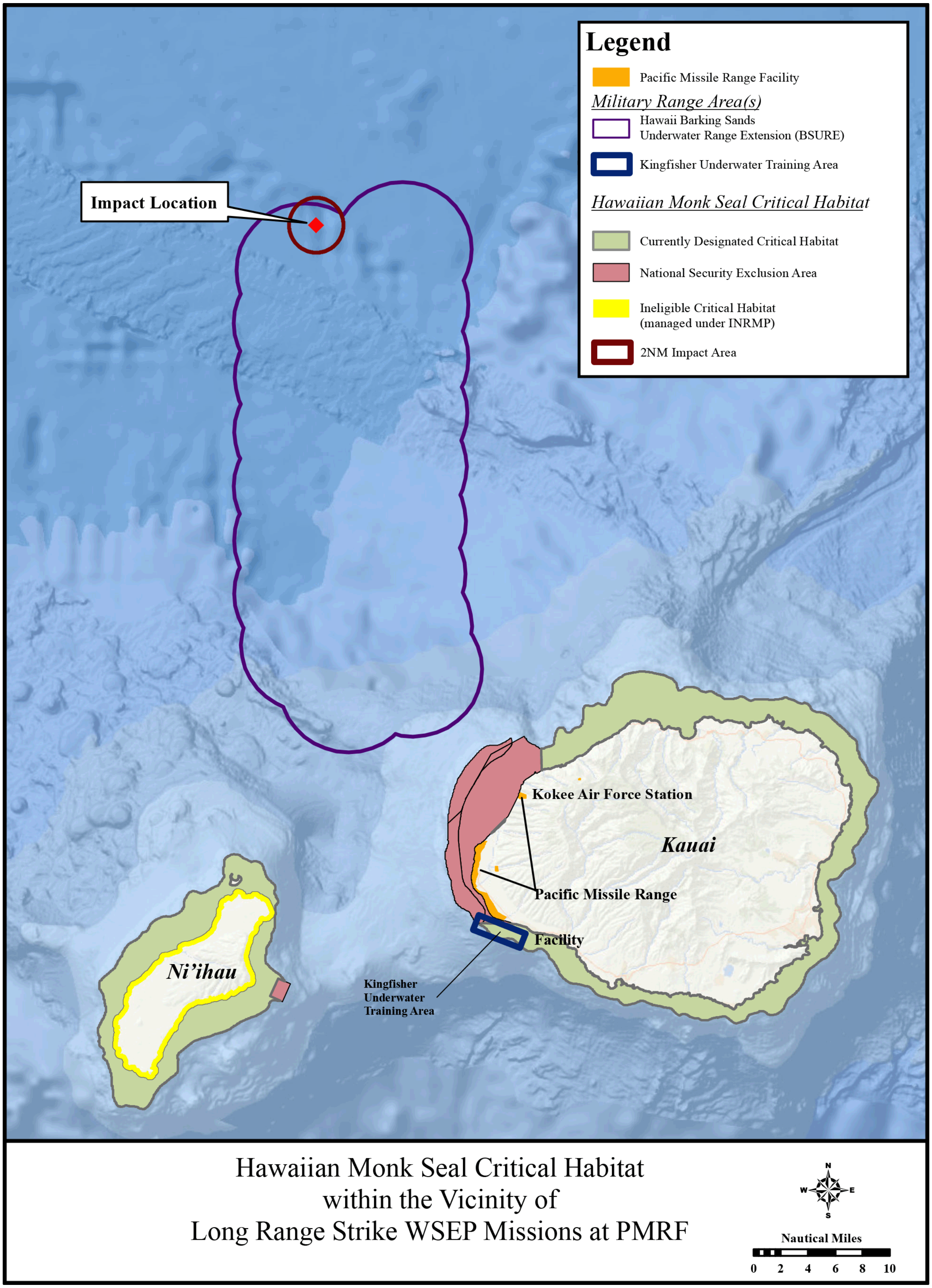
In 2008, NMFS received a petition requesting that the critical habitat in the Northwestern Hawaiian Islands be expanded to include Sand Island at Midway and ocean waters out to a depth of 500 meters and that the following critical habitat be added in the Main Hawaiian Islands: key beach areas, sand spits and islets, lagoon waters, inner reef waters, and ocean waters to a depth of 200 meters. In 2009, NMFS announced a 12-month finding indicating the intention to revise critical habitat, and in 2011 NMFS proposed that critical habitat in the Northwestern Hawaiian Islands be expanded to include Sand Island at Midway and ocean waters out to a depth of 500 meters and that six new extensive areas in the Main Hawaiian Islands be added. In August 2015, NMFS published a final rule revising critical habitat designation to include 10 areas in the Northwestern Hawaiian Islands and 6 areas in the Main Hawaiian Islands (50 CFR Part 226, August 21, 2015). NMFS excluded several areas from designation because either (1) the national security benefits of exclusion outweigh the benefits of inclusion (and exclusion will not result in extinction of the species), or (2) they are managed under Integrated Natural Resource Management Plans that provide a benefit to the species (these areas are termed “ineligible”). Critical Habitat Specific Area 13 includes portions of the Kauai coastline and associated marine waters. However, portions of the PMRF were excluded, including the PMRF Main Base at Barking Sands and the PMRF Offshore Areas in marine areas off the western coast of Kauai. Hawaiian monk seal critical habitat is shown in Figure 3.8-1.

The Pacific Island Regional Office of NMFS has the lead responsibility for the recovery of Hawaiian monk seals under the ESA and the MMPA. Since the early 1980s, NMFS has routinely applied flipper tags to weaned pups in the Northwestern Hawaiian Islands (Antonelis et al., 2006). NMFS performed capture and release programs through the Head Start Program between 1981 and 1991, “to enhance the survival of young females and thereby increase their subsequent recruitment into the adult female population.” From 1984 to 1995, under NMFS’s Rehabilitation Project, undersized, weaned female pups from French Frigate Shoals and, in some cases, undersized juvenile females, were brought into captivity for 8 to 10 months on Oahu to increase their weight. They were then released into the wild at either Kure Atoll or Midway Islands, where they had a higher probability of survival (Antonelis et al., 2006). Because some males were injuring female seals, in July and August of 1994, 21 adult male Hawaiian monk seals were relocated from Laysan Island to the Main Hawaiian Islands (NMFS, 2009). NMFS has relocated three female monk seals (a juvenile in 1981, a pup in 1991, and an adult in 2009) from the Main Hawaiian Islands to the Northwestern Hawaiian Islands (NMFS, 2009).

Other agencies that also play an important role in the Northwestern Hawaiian Islands are the Marine Mammal Commission; the USFWS, which manages wildlife habitat and human activities within the lands and waters of the Hawaiian Islands National Wildlife Refuge and the Midway Atoll National Wildlife Refuge; the U.S. Coast Guard, which assists with enforcement and efforts to clean up marine pollution; the National Ocean Service, which conserves natural resources in the Northwestern Hawaiian Islands Coral Reef Ecosystem Reserve; and the Western Pacific Regional Fishery Management Council (WPRFMC), which develops fishery management plans (FMPs) and proposes regulations to NMFS for commercial fisheries around the Northwestern Hawaiian Islands (Marine Mammal Commission, 2002).

In addition, the State of Hawaii has important responsibilities for monk seal conservation and recovery. It owns Kure Atoll and has jurisdiction over waters between the reserve boundary and 3 NM around all emergent lands in the Northwestern Hawaiian Islands (except Midway) (Marine Mammal Commission, 2002). In March 2007, the State of Hawaii put new regulations into place to restrict the use of lay nets on Oahu, Molokai, Lanai, Kauai, and Niihau and prohibited lay net use in state waters around the entire island of Maui and certain areas on Oahu (NMFS, 2010b). In 2008, in hopes of raising awareness of the species, Hawaii’s lieutenant governor signed into law legislation that established the Hawaiian monk seal as the official state mammal.

Figure 3.8-1. Critical Habitat of the Hawaiian Monk Seal near the Study Area



When seals are reported on beaches in the main islands, NMFS works with state and local agencies to cordon off sections of beach around the seals. NMFS also relies on volunteer groups to observe seals and educate the public about their endangered status and protection measures. On Oahu, the Hawaiian Monk Seal Response Team Oahu is a team of over 50 volunteers who routinely assist NMFS Pacific Island Regional Office and the Pacific Island Fisheries Science Center in monk seal response issues. Monk seal response programs also exist on Kauai, Maui, and the Island of Hawaii, with some reporting from Molokai and Lanai (NMFS, 2010c).

There is also a multiagency marine debris working group that was established in 1998 to remove derelict fishing gear, which has been identified as a top threat to this species, from the Northwestern Hawaiian Islands (Donohue and Foley, 2007). Agencies involved in these efforts include The Ocean Conservancy, the City and County of Honolulu, the Coast Guard, the USFWS, the Hawaii Wildlife Fund, the Hawaii Sea Grant Program, the National Fish and Wildlife Foundation, the Navy, the University of Alaska Marine Advisory Program, and numerous other state and private agencies and groups (Marine Mammal Commission, 2002).

The Navy has previously funded some monk seal tagging projects conducted by Pacific Islands Fisheries Science Center personnel. In addition, since 2013, some collaborative projects have been undertaken under the PMRF Integrated Natural Resources Management Plan.

Geographic Range and Distribution

General. Monk seals can rapidly cover large areas in search of food and may travel hundreds of miles in a few days (Littnan et al., 2007).

Insular Pacific-Hawaiian Large Marine Ecosystem. The Hawaiian monk seal is the only endangered marine mammal whose range is entirely within the United States (NMFS, 2007b). Hawaiian monk seals can be found throughout the Hawaiian Island chain in the Insular Pacific-Hawaiian Large Marine Ecosystem. Sightings have also occasionally been reported on nearby island groups south of the Hawaiian Island chain, such as Johnston Atoll, Wake Island, and Palmyra Atoll (Gilmartin and Forcada, 2009; Jefferson et al., 2015; NMFS, 2009). The main breeding sites are in the Northwestern Hawaiian Islands: French Frigate Shoals, Laysan Island, Lisianski Island, Pearl and Hermes Reef, Midway Atoll, Kure Atoll, and Necker and Nihoa Islands. Monk seals have also been observed at Gardner Pinnacles and Maro Reef. A small breeding population of monk seals is found throughout the Main Hawaiian Islands, where births have been documented on most of the major islands, especially Kauai (Gilmartin and Forcada, 2009; NMFS, 2007b, 2010b). It is possible that, before Western contact, Polynesians destroyed the Hawaiian monk seals from the Main Hawaiian Islands and that the seals were driven to less desirable habitat in the Northwestern Hawaiian Islands (Baker and Johanos, 2004).

Although the Hawaiian monk seal is found primarily on the Northwestern Hawaiian Islands (NMFS Service, 2014), sightings on the Main Hawaiian Islands have become more common (Johanos et al., 2015). During Navy-funded marine mammal surveys from 2007 through to 2012, there were 41 sightings of Hawaiian monk seals for a total of 58 individuals on (or near) Kauai, Kaula, Niihau, Oahu, and Molokai (HDR, 2012). Forty-seven (81 percent) individuals were seen during aerial surveys, and 11 (19 percent) during vessel surveys. Monk seals were most frequently observed at Niihau.

Monk seals spend most of their time at sea in nearshore, shallow marine habitats (Littnan et al., 2007). When hauled out, Hawaiian monk seals seem to prefer beaches of sand, coral rubble, and rocky terraces (Baker et al., 2006; Jefferson et al., 2015).

Climate models predict that global average sea levels may rise this century, potentially affecting species that rely on the coastal habitat. Topographic models of the low-lying Northwestern Hawaiian Islands were created to evaluate potential effects of sea level rise by 2100. Monk seals, which require the islands for resting, molting, and nursing, may experience more crowding and competition if islands shrink (Baker et al., 2006).

Population and Abundance

Currently, the best estimate for the total population of monk seals is 1,112 (Carretta et al., 2016). Population dynamics at the different locations in the Northwestern Hawaiian Islands and the Main Hawaiian Islands has varied considerably (Antonelis et al., 2006). A population model for the years 2003–2012 suggests a decline in overall population of about 3.3 percent. However, the Main Hawaiian Island population appears to be increasing, possibly at a rate of about 7 percent per year (NMFS, 2014). In the Main Hawaiian Islands, a minimum abundance of 45 seals was found in 2000, and this increased to 52 in 2001 (Baker, 2004). In 2009, 113 individual seals were identified in the Main Hawaiian Islands based on flipper tag identification numbers or unique natural markings. The total number in the Main Hawaiian Islands is currently estimated to be about 200 animals (NMFS, 2016). Beach counts in the Northwestern Hawaiian Islands since the late 1950s have shown varied population trends over time, but in general, abundance is low at most islands (NMFS, 2014).

Possible links between the spatial distribution of primary productivity in the Northwestern Hawaiian Islands and trends of Hawaiian monk seal abundance have been assessed for the past 40 years or more. Results demonstrate that monk seal abundance trends appear to be affected by the quality of local environmental conditions (including sea surface temperature, vertical water column structure, and integrated chlorophyll) (Schmelzer, 2000). Limited prey availability may be restricting the recovery of the Northwestern Hawaiian Islands monk seals (Baker, 2008; Brillinger et al., 2006; Carretta et al., 2016). Studies performed on pup survival rate in the Northwestern Hawaiian Islands between 1995 and 2004 showed severe fluctuations, between 40 percent and 80 percent survival in the first year of life. Survival rates between 2004 and 2008 showed an increase at Lisianski Island and Pearl, Hermes, Midway, and Kure Atoll and a decrease at French Frigate Shoals and Laysan Island. Larger females have a higher survival rate than males and smaller females (Baker, 2008).

Estimated chances of survival from weaning to age one are higher in the Main Hawaiian Islands (77 percent) than in the Northwestern Hawaiian Islands (42 to 57 percent) (Littnan, 2011). The estimated intrinsic rate of population growth in the Main Hawaiian Islands is greater as well. If current trends continue, abundances in the Main Hawaiian Islands could eventually exceed that of the Northwestern Hawaiian Islands (NMFS, 2014). There are a number of possible reasons why pups in the Main Hawaiian Islands are faring better. One is that the per capita availability of prey may be higher in the Main Hawaiian Islands, due to the low monk seal population (Baker and Johanos, 2004). Another may have to do with the structure of the marine communities. In the Main Hawaiian Islands, the seals have less competition with other top predators, like large sharks, jacks, and other fish, which may enhance their foraging success (Baker and Johanos, 2004; Parrish et al., 2008).

A third factor may be the limited amount of suitable foraging habitat in the Northwestern Hawaiian Islands (Stewart et al., 2006). While foraging conditions are better in the Main Hawaiian Islands than in the Northwestern Hawaiian Islands, health hazards from exposure to pollutants and infectious disease agents associated with terrestrial animals pose risks not found in the Northwestern Hawaiian Islands (Littnan et al., 2007). Despite these risks, a self-sustaining subpopulation in the Main Hawaiian Islands could improve the monk seal's long-term prospects for recovery (Baker and Johanos, 2004; Carretta et al., 2005; Marine Mammal Commission, 2003).

Predator/Prey Interactions

The Hawaiian monk seal is a foraging generalist, often moving rocks to capture prey underneath (NMFS, 2014). Monk seals feed on many species of fish, cephalopods, and crustaceans. Prey species include representatives of at least 31 bony fish families, 13 cephalopod (octopus, squid, and related species) families, and numerous crustaceans (e.g., crab and lobster). Foraging typically occurs on the seafloor from the shallows to water depths greater than 500 meters. Data from tagged individuals indicate foraging occurs primarily in areas of high bathymetric relief within 40 kilometers (25 miles) of atolls or islands, although submerged banks and reefs located over 300 kilometers from breeding sites may also be used (NMFS, 2014). In general, seals associated with the Main Hawaiian Islands appear to have smaller home ranges, travel shorter distances to feed, and spend less time foraging than seals associated with the Northwestern Hawaiian Islands. The inner reef waters next to the islands are critical to weaned pups learning to feed; pups move laterally along the shoreline but do not appear to travel far from shore during the first few months after weaning (Gilmartin and Forcada, 2009). Feeding has been observed in reef caves, as well as on fish hiding among coral formations (Parrish et al., 2000). A recent study showed that this species is often accompanied by large predatory fish, such as jacks, sharks, and snappers, which possibly steal or compete for prey that the monk seals flush with their probing, digging, and rock-flipping behavior. The juvenile monk seals may not be of sufficient size or weight to get prey back once it has been stolen. This was noted only in the French Frigate Shoals (Parrish et al., 2008).

Monk seals and are known to be preyed on by both killer whales and sharks. Shark predation is one of the major sources of mortality for this species, especially in the Northwestern Hawaiian Islands. Galapagos sharks are a large source of juvenile mortality in the Northwestern Hawaiian Islands, with most predation occurring in the French Frigate Shoals (Antonelis et al., 2006; Gilmartin and Forcada, 2009; Jefferson et al., 2015).

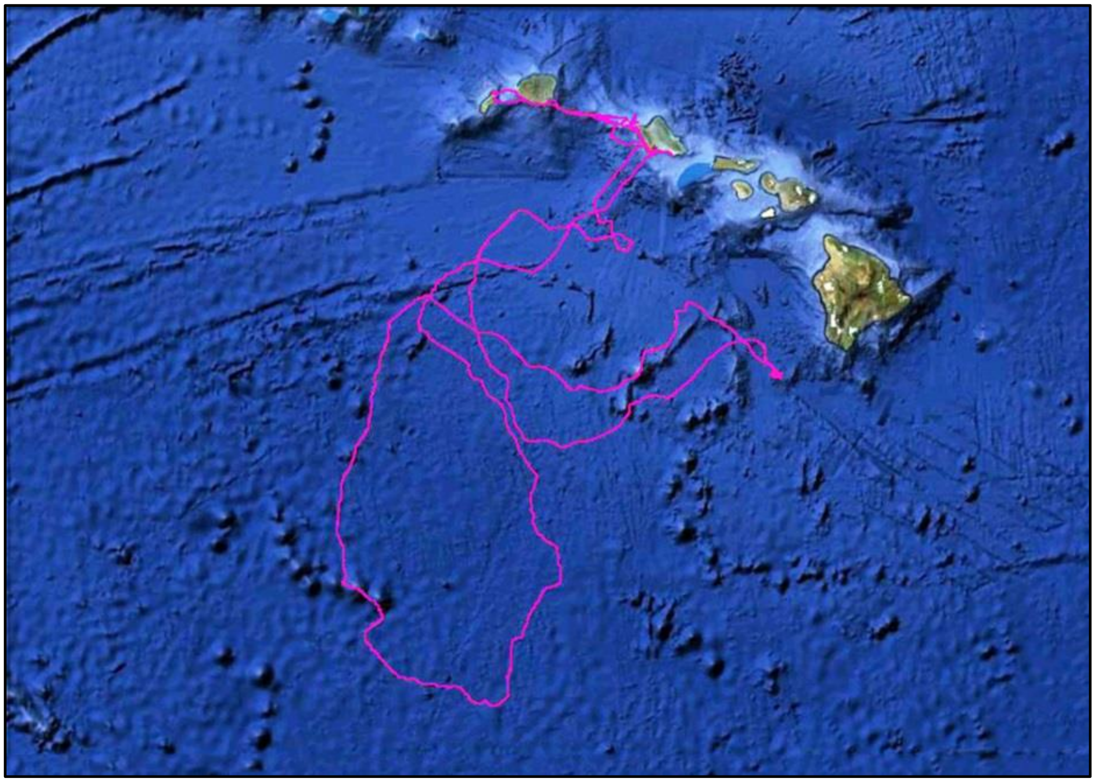
In an effort to better understand the habitat needs of foraging monk seals, Stewart et al., (2006) used satellite-linked radio transmitters to document the geographic and vertical foraging patterns of 147 Hawaiian monk seals from all six Northwestern Hawaiian Islands breeding colonies from 1996 through 2002. Geographic patterns of foraging were complex and varied among colonies by season, age, and sex, but some general patterns were evident. Seals were found to forage extensively within barrier reefs of the atolls and on the leeward slopes of reefs and islands at all colony sites. They also ranged away from these sites along the Hawaiian Islands submarine ridge to most nearby seamounts and submerged reefs and banks (Stewart et al., 2006).

In 2005, 11 juvenile and adult monk seals were tracked in the Main Hawaiian Islands using satellite-linked radio transmitters showing location but not depth (Littnan et al., 2007). Similar to the Northwestern Hawaiian Islands, monk seals showed a high degree of individual variability. Overall results showed most foraging trips to last from a few days to one to two weeks, with seals remaining within the 200-meter isobaths surrounding the Main Hawaiian Islands and nearby banks (Littnan et al., 2007).

NMFS and the Navy have also monitored monk seals with cell phone tags (Littnan, 2011; Reuland, 2010). Results from one individual monk seal (R012) indicated travel of much greater distances and water depths than previously documented (Littnan, 2011). The track of this monk seal extended as much as 470 miles (756.4 kilometers) from shore and a total distance of approximately 2,000 miles (3,218.7 kilometers) where the ocean is over 5,000 meters in depth (Figure 3.8-2). However, the distance traveled by this individual was substantially greater than that of foraging trips undertaken by other seals in the study and may not represent typical behavior (Littnan, 2012).

Figure 3.8-2. Track of Hawaiian Monk Seal R012 in June 2010

Source: NMFS, 2010f



Species-Specific Threats

Monk seals are particularly susceptible to fishery interactions and entanglements. In the Northwestern Hawaiian Islands, derelict fishing gear has been identified as a top threat to the monk seal (Donohue and Foley, 2007), while in the Main Hawaiian Islands, high risks are associated with health hazards from exposure to pollutants and infectious disease agents associated with terrestrial animals. Limited prey availability may be restricting the recovery of the Northwestern Hawaiian Islands monk seals (Baker, 2008; Brillinger et al., 2006; Carretta et al., 2016). Since they rely on coastal habitats for survival, monk seals may be affected by future sea level rise and loss of habitat as predicted by global climate models. Another species-specific threat includes aggressive male monk seals that have been documented to injure and sometimes kill females and pups (NMFS, 2010b). Other threats include reduced prey availability, shark predation, disease and parasites, and contaminants (NMFS, 2014).

3.8.2.2 Sea Turtles

This section describes sea turtles potentially found in the BSURE area (referred to as the study area). The status of sea turtle populations is determined primarily from assessments of the adult female nesting populations. Much less is known about other life stages of these species (Mrosovsky et al., 2009, Schofield et al., 2010, Witt et al., 2010). The National Research Council (2010) recently reviewed the current state of sea turtle research and concluded that relying too much on nesting beach data limits a more complete understanding of sea turtles and the evaluation of management options for their overall health and recovery.

Five sea turtle species are potentially found in the study area, and all are listed under the ESA as endangered or threatened. Table 3.8-4 lists the species with potential occurrence and their ESA status.

Table 3.8-4. Sea Turtles Potentially Occurring in the Study Area

Common Name	Scientific Name	Endangered Species Act Status
Green sea turtle	*Chelonia mydas*	Threatened
Hawksbill sea turtle	*Eretmochelys imbricata*	Endangered
Loggerhead sea turtle	*Caretta caretta*	Endangered
Olive ridley sea turtle	*Lepidochelys olivacea*	Threatened
Leatherback sea turtle	*Dermochelys coriacea*	Endangered

Sea turtles are highly migratory and are present in coastal and open ocean waters of the study area. Most sea turtles prefer to live in warm waters, because they are cold-blooded reptiles. Leatherbacks are the exception and are more likely to be found in colder waters at higher latitudes because of their unique ability to maintain an internal body temperature higher than that of the environment (Dutton, 2006). Habitat use varies among species and within the life stages of individual species, correlating primarily with the distribution of preferred food sources, as well as the locations of nesting beaches.

Habitat and distribution vary among species and life stages and are discussed further in the species profiles below. Little information is available about sea turtles' stage of life after hatching. Open-ocean juveniles spend an estimated 2 to 14 years drifting, foraging, and developing. Because of the general lack of knowledge of this period, it has been described as "the lost years." After this period, juvenile hawksbill (*Eretmochelys imbricata*), olive ridley, loggerhead, and green turtles settle into coastal habitat, with individuals often remaining associated with a specific home range until adulthood (Bjorndal and Bolten, 1988; NMFS and USFWS, 1991). Leatherback turtles remain primarily in the open ocean throughout their lives, except for mating in coastal waters and females going ashore to lay eggs. All species can migrate long distances across large expanses of the open ocean, primarily between nesting and feeding grounds (NMFS and USFWS, 2007b).

All sea turtle species are believed to use a variety of orientation mechanisms on land and at sea (Lohmann et al., 1997). After emerging from the nest, hatchling turtles use visual cues, such as light wavelengths and shape patterns, to find the ocean (Lohmann et al., 1997). Once in the ocean, hatchlings use wave cues to navigate offshore (Lohmann and Lohmann, 1992). In the open ocean, turtles in all life stages are thought to orient to the earth's magnetic field to position themselves in oceanic currents; this helps them locate seasonal feeding and breeding grounds and return to their nesting sites (Lohmann and Lohmann, 1996; Lohmann et al., 1997). The stimuli that help sea turtles find their nesting beaches are still poorly understood, particularly the fine-scale navigation that occurs as turtles approach the site, and could also include chemical and acoustic cues.

Diving

Sea turtle dive depth and duration varies by species, the age of the animal, the location of the animal, and the activity (i.e., foraging, resting, migrating). The diving behavior of a particular species or individual has implications for mitigation and monitoring. In addition, their relative distribution throughout the water column is an important consideration when conducting acoustic exposure analyses. The following text briefly describes the dive behavior of each species.

Green sea turtle. In the open ocean, Hatase et al. (2006) observed that green sea turtles dive to a maximum of 260 feet (79 meters). Open-ocean resting dives rarely exceed 50 feet (15 meters), while most open-ocean foraging dives average about 80 feet (24 meters) (Hatase et al., 2006). A difference in duration between night and day dives was observed, with day dives lasting 1 to 18 minutes and night dives averaging 35 to 44 minutes (Rice and Balazs, 2008). In their coastal habitat, green sea turtles typically make dives shallower than 100 feet (31 meters), with most dives not exceeding 58 feet (18 meters) (Hays, Houghton, et al., 2004; Rice and Balazs, 2008). Green sea turtles are known to forage and also rest at depths of 65 to 165 feet (20 to 50 meters) (Balazs, 1980; Brill et al., 1995).

Hawksbill turtle. Hawksbill turtles make short, active foraging dives during the day and longer resting dives at night (Blumenthal et al., 2009; Storch et al., 2005; Van Dam and Diez, 1996). Lutcavage and Lutz (1997) cited a maximum dive duration of 73.5 minutes for a female hawksbill in the U.S. Virgin Islands. Van Dam and Diez (1996) reported that foraging dives at a study site in the northern Caribbean ranged from 19 to 26 minutes at depths of 25 to 35 feet (8 to 11 meters), with resting night dives ranging from 35 to 47 minutes (Van Dam and Diez, 1996). Foraging dives of immature hawksbills are shorter, ranging from 8.6 to 14 minutes in duration (Van Dam and Diez, 1996), with a mean and maximum depth of 5 feet (1.5 meters) and 65 feet (20 meters), respectively (Blumenthal et al., 2009; Van Dam and Diez, 1996).

Loggerhead turtle. Loggerhead turtles foraging in nearshore habitat dive to the seafloor (average depth 165 to 490 feet [50 to 149 meters]), and those in open-ocean habitat dive from 0 to 80 feet (0 to 24 meters) (Hatase et al., 2007). Dive duration was significantly longer at night and increased in warmer waters. The average overall dive duration was 25 minutes, although dives exceeding 300 minutes were recorded. Turtles in open-ocean habitat exhibited mid-water resting dives at around 45 feet (14 meters), where they could remain for many hours. This (resting) appears to be the main function of many of the night dives recorded (Hatase et al., 2007). Another study on coastal foraging loggerheads found that virtually all dives were shallower than 100 feet (31 meters) (Sakamoto et al., 1993).

On average, loggerhead turtles spend over 90 percent of their time underwater (Byles, 1988; Renaud and Carpenter, 1994). Studies investigating dive characteristics of loggerheads under various conditions confirm that loggerheads do not dive particularly deep in the open-ocean environment (approximately 80 feet [24 meters]) but will forage to bottom depths of at least 490 feet (149 meters) in coastal habitats (Hatase et al., 2007; Polovina et al., 2002; Soma, 1985).

Olive ridley sea turtle. Most studies on olive ridley diving behavior have been conducted in shallow coastal waters (Beavers and Cassano, 1996; Sakamoto et al., 1993). However, Polovina et al. (2002) radio-tracked two olive ridleys (and two loggerheads) caught in commercial fisheries. The results showed that the olive ridleys dove deeper than loggerheads but spent only about 10 percent of time at depth under 100 feet (31 meters). Daily dives of 200 meters (656 feet) occurred, with one dive recorded at 254 meters (833 feet) (Polovina et al., 2002). The deeper-dive distribution of olive ridleys is also consistent with their oceanic habitat, which differs from the loggerhead habitat.

Leatherback sea turtle. The leatherback is the deepest diving sea turtle, with a recorded maximum depth of 4,200 feet (1,280 meters), although most dives are much shallower (usually less than 820 feet [250 meters]) (Hays, Houghton, et al., 2004; Sale et al., 2006). Diving activity (including surface time) is influenced by a suite of environmental factors (e.g., water temperature, availability and vertical distribution of food resources, bathymetry) that result in spatial and temporal variations in dive behavior (James et al., 2006; Sale et al., 2006). Leatherbacks dive deeper and longer in the lower latitudes than in the higher latitudes (James et al., 2005a), where they are known to dive in waters with temperatures just above freezing (James et al., 2006; Jonsen et al., 2007). James et al. (2006) noted that dives in higher latitudes are punctuated by longer surface intervals, perhaps in part to thermoregulate (i.e., bask). Tagging data also revealed that changes in individual turtle diving activity appear to be related to water temperature, suggesting an influence of seasonal prey availability on diving behavior (Hays, Houghton, et al., 2004). In their warm-water nesting habitats, dives are likely constrained by bathymetry adjacent to nesting sites during this time (Myers and Hays, 2006). For example, patterns of relatively deep diving are recorded off St. Croix in the Caribbean (Eckert et al., 1986) and Grenada (Myers and Hays, 2006) in areas where deep waters are close to shore. A maximum depth of 1,560 feet (476 meters) was recorded (Eckert et al., 1986), although even deeper dives were inferred where dives exceeded the maximum range of the time-depth recorder (Eckert et al., 1989a). Shallow diving occurs where shallow water is close to the nesting beach.

Information on the diving behavior of each species of sea turtle was compiled in a Navy Technical Report (DoN, 2011) that summarizes time at depth for the purpose of distributing animals within the water column for acoustic exposure modeling.

Vocalization and Hearing

The auditory system of sea turtles appears to work via water and bone conduction, with lower-frequency sound conducted through the skull and shell, and does not appear to function well for hearing in air (Lenhardt et al., 1983, 1985). Sea turtles do not have external ears or ear canals to channel sound to the middle ear, nor do they have a specialized eardrum. Instead, fibrous and fatty tissue layers on the side of the head may be the sound-receiving membrane in the sea turtle, a function similar to that of the eardrum in mammals, or may serve to release energy received via bone conduction (Lenhardt et al., 1983). Sound is transmitted to the middle ear, where sound waves cause movement of cartilaginous and bony structures that interact with the inner ear (Ridgway, 1969). Unlike mammals, the cochlea of the sea turtle is not elongated and coiled and likely does not respond well to high frequencies, a hypothesis supported by a limited amount of information on sea turtle auditory sensitivity (Ridgway, 1969; Bartol, 1999).

Investigations suggest that sea turtle auditory sensitivity is limited to low-frequency bandwidths, such as those produced by waves breaking on a beach. The role of underwater low-frequency hearing in sea turtles is unclear. Sea turtles may use acoustic signals from their environment as guideposts during migration and as cues to identify their natal beaches (Lenhardt et al., 1983). Sea turtles are low-frequency hearing specialists, typically hearing frequencies from 30 to 2,000 Hz, with a range of maximum sensitivity between 100 and 800 Hz (Bartol, 1999; Ridgway, 1969; Lenhardt, 1994; Bartol and Ketten, 2006; Lenhardt, 2002). Hearing below 80 Hz is less sensitive but still potentially usable (Lenhardt, 1994). Greatest sensitivities are from 300 to 400 Hz for the green sea turtle (Ridgway, 1969) and around 250 Hz or below for juvenile loggerheads (Bartol, 1999). Bartol et al. (1999) reported that the range of effective hearing for juvenile loggerhead sea turtles is from at least 250 to 750 Hz using the auditory brainstem response technique. Juvenile and sub-adult green sea turtles detect sounds from 100 to 500 Hz underwater, with maximum sensitivity at 200 and 400 Hz (Bartol and Ketten, 2006). Auditory brainstem response recordings on green sea turtles showed a peak response at 300 Hz (Yudhana et al., 2010). Juvenile Kemp’s ridley turtles detected underwater sounds from 100 to 500 Hz, with a maximum sensitivity between 100 and 200 Hz (Bartol and Ketten, 2006). Audiometric information is not available for leatherback sea turtles; however, their anatomy suggests they would hear similarly to other sea turtles. Functional hearing is assumed to be 10 Hz to 2 kilohertz (kHz).

Sub-adult green sea turtles show, on average, the lowest hearing threshold at 300 Hz (93 decibels referenced to 1 micropascal [dB re 1 µPa]), with thresholds increasing at frequencies above and below 300 Hz, when thresholds were determined by auditory brainstem response (Bartol and Ketten, 2006). Auditory brainstem response testing was also used to detect thresholds for juvenile green sea turtles (lowest threshold 93 decibels referenced to 1 micropascal [dB re 1 µPa at 600 Hz]) and juvenile Kemp’s ridley sea turtles (thresholds above 110 dB re 1 µPa across hearing range) (Bartol and Ketten, 2006). Auditory thresholds for yearling and two-year-old loggerhead sea turtles were also recorded. Both yearling and two-year-old loggerhead sea turtles had the lowest hearing threshold at 500 Hz (yearlings at approximately 81 dB re 1 µPa and two-year-olds at approximately 86 dB re 1 µPa), with thresholds increasing rapidly above and below that frequency (Bartol and Ketten, 2006). In terms of sound production, nesting leatherback turtles were recorded producing sounds (sighs or belch-like sounds) up to 1,200 Hz, with most energy ranging from 300 to 500 Hz (Bartol and Ketten, 2006).

General Threats

The sea turtle species in the study area have unique life histories and habitats; however, threats are common among all species. On beaches, wild domestic dogs, pigs, and other animals ravage sea turtle nests. Humans continue to harvest eggs and nesting females in some parts of the world, threatening some Pacific Ocean sea turtle populations (Maison et al., 2010). Coastal development can cause beach erosion and introduce nonnative vegetation, leading to a subsequent loss of nesting habitat. It can also introduce or increase the intensity of artificial light, confusing hatchlings and leading them away from the water, thereby increasing the chances of hatchling mortality. Threats in nearshore foraging habitats include fishing and habitat degradation. Fishing can injure or drown juvenile and adult sea turtles. Habitat degradation, such as poor water quality, invasive species, and disease, can alter ecosystems, limiting the availability of food and altering survival rates.

By-catch in commercial fisheries, ship strikes, and marine debris are primary threats in the offshore environment (Lutcavage, 1997). One comprehensive study estimated that, worldwide, 447,000 sea turtles are killed each year from by-catch in commercial fisheries (Wallace et al., 2010). Precise data are lacking for sea turtle mortalities directly caused by ship strikes. However, live and dead turtles are often found with deep cuts and fractures indicative of collision with a boat hull or propeller (Lutcavage, 1997; Hazel, 2007). Marine debris can also be a problem for sea turtles through entanglement or ingestion. Floating plastic garbage can be mistakenly ingested by sea turtles. Leatherback sea turtles in particular may mistake floating plastic garbage as jellyfish, an important component of the leatherback diet (Mrosovsky et al., 2009). Other marine debris, including derelict fishing gear and cargo nets, can entangle and drown turtles of all life stages.

Similar to the marine mammal discussion, all sea turtle species are federally protected under the ESA. The species descriptions in the following subsections follow the framework for assessing impacts and making determinations under Section 7 of the ESA and are also included in the Biological Assessment.

3.8.2.2.1 Green Sea Turtle (*Chelonia mydas*)

The green sea turtle is found in tropical and subtropical coastal and open ocean waters, between 30° N and 30° S. Major nesting beaches are found throughout the western and eastern Atlantic, Indian, and western Pacific Oceans, including more than 80 countries worldwide (Hirth, 1997).

Status and Management

The green sea turtle was listed under the ESA in July 1978 because of excessive commercial harvest, a lack of effective protection, evidence of declining numbers, and habitat degradation and loss (NMFS and USFWS, 2007a). Recently, NMFS and USFWS revised DPS designations and corresponding ESA status for the green sea turtle, identifying three DPSs as endangered and eight DPSs as threatened (50 CFR Parts 223 and 224, April 6, 2016). The Central North Pacific DPS, which includes the Hawaiian Archipelago, is listed as threatened. Critical habitat is not currently designated for the Central North Pacific DPS but could potentially be proposed in future rulemaking. Recovery plans have been prepared for Pacific Ocean green sea turtles (western and central Pacific populations) (NMFS and USFWS, 1998a).

Habitat and Geographic Range

Green sea turtles nest on beaches within the Insular Pacific-Hawaiian Large Marine Ecosystem. The eggs incubate in the sand for approximately 48 to 70 days. Green sea turtle hatchlings are 2 inches (5 centimeters) long, and weigh approximately 1 ounce (ounce) (28 grams). When they leave the nesting beach, hatchlings begin an oceanic phase (Carr, 1987), floating passively in current systems (gyres), where they develop (Carr and Meylan, 1980). Hatchlings live at the surface in the open ocean for approximately one to three years (Hirth, 1997). Upon reaching the juvenile stage (estimated at five to six years and shell length of 8 to 10 inches [20 to 25 centimeters]), they move to lagoons and coastal areas that are rich in seagrass and algae (Bresette et al., 2006; Musick and Limpus, 1997). The optimal habitats for late juveniles and adults are warm, quiet, shallow waters (depths of 10 to 33 feet) (3 to 10 meters), with seagrasses and algae, that are near reefs or rocky areas used for resting (Makowski et al., 2006). This habitat is where they will spend most of their lives (Bjorndal and Bolten, 1988; Makowski et al., 2006; NMFS and USFWS, 1991). A small number of green sea turtles appear to remain in the open ocean for extended periods, perhaps never moving to coastal feeding sites (NMFS and USFWS, 2007a; Pelletier et al., 2003).

Green sea turtles are known to live in the open ocean during the first five to six years of life, but little is known about preferred habitat or general distribution during this life phase. Migratory routes within the open ocean are unknown. The main source of information on distribution comes from catches in U.S. fisheries. About 57 percent of green sea turtles (primarily adults) captured in longline fisheries in the North Pacific Subtropical Gyre and North Pacific Transition Zone come from the Mexican nesting population, while 43 percent are from the Hawaiian nesting populations. The Hawaii-based longline tuna fishery is active on the high seas, between 15 °N and 35° N and 150° West (W) to 180° W. The Hawaii-based longline swordfish fishery is active on the high seas northeast of the Hawaiian Islands in the North Pacific Transition Zone (Gilman et al., 2007). These findings suggest that green sea turtles found on the high seas of the western and central Pacific Ocean are from these two populations.

Green sea turtles are estimated to reach sexual maturity at 20 to 50 years of age. This prolonged time to maturity has been attributed to their low-energy plant diet (Bjorndal, 1995) and may be the highest age for maturity of all sea turtle species (Chaloupka and Musick, 1997; Hirth, 1997; NMFS and USFWS, 2007a).

Once mature, green sea turtles may reproduce for a span of 17 to 23 years, nesting every two to five years (Carr et al., 1978; Hirth, 1997). This irregular pattern can cause wide year-to-year changes in numbers of nesting females at a given nesting beach. Each female nests three to five times per season, laying an average of 115 eggs in each nest (clutch). A female green sea turtle may deposit 9 to 33 clutches in a lifetime. With an average of approximately 100 eggs per nest, a female green sea turtle may lay 900 to 3,300 eggs in a lifetime (NMFS and USFWS, 2007a).

When green sea turtles are not breeding, adults live in coastal feeding areas that they sometimes share with juveniles (Seminoff and Marine Turtle Specialist Group Green Turtle Task Force, 2004). Green sea turtles of all ages have a dedicated home range in which they repeatedly visit the same feeding and breeding areas (Bresette et al., 1998; Makowski et al., 2006).

The green sea turtle is the most common sea turtle species in the Hawaii region, occurring in the coastal waters of the Main Hawaiian Islands throughout the year and commonly migrating seasonally to the Northwestern Hawaiian Islands to reproduce. In the spring of 2010, two green sea turtles nested at PMRF for the first time in more than a decade, with successful hatching in August 2010 (O’Malley, 2010). Green sea turtles are found in inshore waters around all of the Main Hawaiian Islands and Nihoa Island, where reefs, their preferred habitats for feeding and resting, are most abundant. They are also common in an oceanic zone surrounding the Hawaiian Islands. This area is frequently inhabited by adults migrating to the Northwestern Hawaiian Islands to reproduce during the summer and by ocean-dwelling individuals that have yet to settle into coastal feeding grounds of the Main Hawaiian Islands. Farther offshore, green sea turtles occur in much lower numbers and densities.

More than 90 percent of all Hawaiian Island green sea turtle breeding and nesting occurs at French Frigate Shoals in the Northwestern Hawaiian Islands, the largest nesting colony in the central Pacific Ocean, where 200 to 700 females nest each year (NMFS and USFWS, 2007a). A large foraging population resides in and returns to the shallow waters surrounding the Main Hawaiian Islands (especially around Maui and Kauai), where they are known to come ashore at several locations on all eight of the Main Hawaiian Islands for basking or nesting.

Population and Abundance

Based on data from 46 nesting sites around the world, between 108,761 and 150,521 female green sea turtles nest each year (NMFS and USFWS, 2007a), which is a 48 to 65 percent decline in the number of females nesting annually over the past 100 to 150 years (Seminoff and Marine Turtle Specialist Group Green Sea Turtle Task Force, 2004). Of nine major nesting populations in the Pacific Ocean, four appear to be increasing (Hawaii, Mexico, Japan, Heron Island), three appear to be stable (Galapagos, Guam, Mexico), and the trend is unknown for two (Central American Coast and Raine Island). In addition to these sites, at least 166 smaller nesting sites are scattered across the western Pacific Ocean, with an estimated 22,800 to 42,580 females nesting in the Pacific Ocean each year (Maison et al., 2010; NMFS and USFWS, 2007a). Outside of the United States, eggs and females are harvested for their meat on nesting beaches across the Pacific Ocean. This activity remains a primary threat to the species (Maison et al., 2010).

In Hawaii, 200 to 700 females nest annually at French Frigate Shoals, as well as on the Island of Hawaii and other minor nesting grounds on other Main Hawaiian Islands (NMFS and USFWS, 2007c). Nesting has been documented in recent years (up to and including 2015) at beach areas of PMRF. Consideration of the Hawaiian population as a distinct stock is under review (Central North Pacific DPS). Individuals spend most of their lives within the Insular Pacific-Hawaiian Large Marine Ecosystem. This population appears to have increased gradually over the past 30 years, with near-capacity nesting at French Frigate Shoals (Balazs and Chaloupka, 2006; Chaloupka et al., 2008a).

Predator and Prey Interactions

The green sea turtle is the only sea turtle that is mostly herbivorous (Mortimer, 1995), although its diet changes throughout its life. While at the surface, hatchlings feed on floating patches of seaweed and, at shallow depths, on comb jellies and gelatinous eggs, appearing to ignore large jellyfish (Salmon et al., 2004). While in the open ocean, juveniles smaller than 8 to 10 inches (20 to 25 centimeters) eat worms, small crustaceans, aquatic insects, grasses, and algae (Bjorndal, 1997). After settling into a coastal habitat, juveniles eat mostly seagrass or algae (Balazs et al., 1994; Mortimer, 1995). Some juveniles and adults that remain in the open ocean, and even those in coastal waters, also consume jellyfish, sponges, and sea pens (Blumenthal et al., 2009; Godley et al., 1998; Hatase et al., 2006; Heithaus et al., 2002; NMFS and USFWS, 2007a; Parker and Balazs, 2005).

Predators of green sea turtles vary according to turtle location and size. Land predators that feed on eggs and hatchlings include ants, crabs, birds, and mammals such as dogs, raccoons, and feral pigs. Aquatic predators, mostly fish and sharks, impact hatchlings most heavily in nearshore areas. Sharks are also the primary predators of juvenile and adult turtles (Stancyk, 1982).

3.8.2.2.2 Hawksbill Sea Turtle (*Eretmochelys imbricata*)

The hawksbill turtle is the most tropical of the world’s sea turtles, rarely occurring higher than 30° N or 30° S in the Atlantic, Pacific, and Indian Oceans (Lazell, 1980). It inhabits coastal waters in more than 108 countries and nests in at least 70 countries (NMFS and USFWS, 2007c).

Status and Management

The hawksbill turtle is listed as endangered under the ESA. Critical habitat has not been designated for the hawksbill in the Pacific Ocean. While the current listing as a single global population remains valid at this time, data may support separating populations at least by ocean basin under the DPS policy (NMFS and USFWS, 2007c), which would lead to specific management plans for each designated population. The hawksbill shell has been prized for centuries for jewelry and other adornments. This trade, prohibited under the Convention on International Trade in Endangered Species, remains a critical threat to the species.

Habitat and Geographic Range

Hawksbills are considered the most coastal of the sea turtles that inhabit the study area, with juveniles and adults preferring coral reef habitats (NMFS, 2010d). Reefs provide shelter for resting hawksbills day and night, and they are known to visit the same resting spot repeatedly. Hawksbills are also found around rocky outcrops and high-energy shoals—optimum sites for sponge growth—as well as in mangrove-lined bays and estuaries (NMFS, 2010d).

Hatchling and early juvenile hawksbills have also been found in the open ocean, in floating mats of seaweed (Maison et al., 2010; Musick and Limpus, 1997). Although information about foraging areas is largely unavailable due to research limitations, juvenile and adult hawksbills may also be present in open ocean environments (NMFS and USFWS, 2007c).

Hawksbills are mostly found in the coastal waters of the eight Main Hawaiian Islands. Stranded or injured hawksbills are occasionally found in the Northwestern Hawaiian Islands (Parker et al., 2009). Hawksbills are the secondmost common species in the offshore waters of the Hawaiian Islands, yet they are far less abundant than green sea turtles (Chaloupka et al., 2008a). The lack of hawksbill sightings during aerial and shipboard surveys likely reflects the species' small size and difficulty in identifying them from a distance.

Hawksbills primarily nest on the southeastern beaches of the Island of Hawaii (Aki et al., 1994). Since 1991, 81 nesting female hawksbills have been tagged on the Island of Hawaii at various locations. This number does not include nesting females from Maui or Molokai, which would add a small number to the total. Post-nesting hawksbills have been tracked moving between Hawaii and Maui over the deep waters of the Alenuihaha Channel (Parker et al., 2009).

Hawksbills were once thought to be nonmigratory because of the proximity of suitable nesting beaches to coral reef feeding habitats and the high rates of marked turtles recaptured in these areas; however, tagging studies have shown otherwise. For example, a post-nesting female traveled 995 miles (1,601 kilometers) from the Solomon Islands to Papua New Guinea (Meylan, 1995), indicating that adult hawksbills can migrate distances comparable to those of green and loggerhead sea turtles. However, research suggests that movements of Hawaiian hawksbills are relatively short, with individuals generally migrating through shallow coastal waters and few deepwater transits between the islands. Nine hawksbill turtles were tracked within the Hawaiian Islands using satellite telemetry. Turtles traveled from 55 to 215 miles (89 to 346 kilometers) and took between 5 and 18 days to complete the trip from nesting to foraging areas (Parker et al., 2009).

Foraging dive durations are often a function of turtle size, with larger turtles diving deeper and longer. Shorter and more active foraging dives occur predominantly during the day, while longer resting dives occur at night (Blumenthal et al., 2009; Storch et al., 2005; Van Dam and Diez, 1997). Lutcavage and Lutz (1997) cited a maximum dive duration of 73.5 minutes for a female hawksbill in the U.S. Virgin Islands. Van Dam and Diez (2000) reported that foraging dives at a study site in the northern Caribbean ranged from 19 to 26 minutes at depths of 26 to 33 feet (8 to 10 meters), with resting night dives from 35 to 47 minutes. Foraging dives of immature hawksbills are shorter, ranging from 8.6 to 14 minutes, with a mean and maximum depth of 16.4 and 65.6 feet (5 and 20 meters), respectively (Van Dam and Diez, 1996). Blumenthal et al. (2009) reported consistent diving characteristics for juvenile hawksbill in the Cayman Islands, with an average daytime dive depth of 25 feet (8 meters), a maximum depth of 140 feet (43 meters), and a mean nighttime dive depth of 15 feet (5 meters). A change in water temperature affects dive duration; cooler water temperatures in the winter result in increased nighttime dive durations (Storch et al., 2005).

Population and Abundance

A lack of nesting beach surveys for hawksbill turtles in the Pacific Ocean and the poorly understood nature of this species' nesting have made it difficult for scientists to assess the population status of hawksbills in the Pacific (NMFS and USFWS, 1998b; Seminoff et al., 2003). An assessment of 25 sites around the world indicates that hawksbill nesting has declined by at least 80 percent over the last three generations (105 years in the Atlantic and 135 years in the Indo-Pacific Ocean) (Meylan and Donnelly, 1999). Only five regional populations remain worldwide (two in Australia and one each in Indonesia, the Seychelles, and Mexico), with more than 1,000 females nesting annually (Meylan and Donnelly, 1999). The largest of these regional populations is in the South Pacific Ocean, where 6,000 to 8,000 hawksbills nest off the Great Barrier Reef (Limpus, 1992).

As with all other turtle species, hawksbill hatchlings enter an oceanic phase and may be carried great distances by surface currents. Although little is known about their open ocean stage, younger juvenile hawksbills have been found in association with brown algae in the Pacific Ocean (Musick and Limpus, 1997; Parker, 1995; Witherington and Hirama, 2006; Witzell, 1983) before settling into nearshore habitats as older juveniles. Preferred habitat is coral reefs, but hawksbills also inhabit seagrass, algal beds, mangrove bays, creeks, and mud flats (Mortimer and Donnelly, 2008). Some juveniles may use the same feeding grounds for a decade or more (Meylan, 1999), while others appear to migrate among several sites as they age (Musick and Limpus, 1997). Indo-Pacific hawksbills are estimated to mature at between 30 and 38 years of age (Mortimer and Donnelly, 2008).

Once they are sexually mature, hawksbill turtles undertake breeding migrations between foraging grounds and breeding areas at intervals of several years (Dobbs et al., 1999; Mortimer and Bresson, 1999; Witzell, 1983). Although females tend to return to breed where they were born (Bowen and Karl, 1997), they may have foraged hundreds or thousands of kilometers from their birth beaches as juveniles.

Hawksbills are solitary nesters. Females nest every two to three years at night. During a single nesting season, a female hawksbill lays between three and five clutches, which contain an average of 130 eggs per clutch (Mortimer and Bresson, 1999; Richardson et al., 1999). In Hawaii, the nesting season runs approximately from May through December (Aki et al., 1994).

The *Hawksbill Sea Turtle (*Eretmochelys imbricata*) 5-Year Review: Summary and Evaluation* (NMFS and USFWS, 2007c) assessed nesting abundance and trends in all regions that the species inhabits. Where possible, historical population trends were determined, and most showed declines for the 20- to 100-year period of evaluation. Recent trends for 42 of the sites indicated that 69 percent were decreasing, 7 percent were stable, and 24 percent were increasing. The Hawaii site has experienced a recent increasing trend.

Predator and Prey Interactions

Hawksbills eat both animals and algae during the early juvenile stage, feeding on prey such as sponges, algae, molluscs, crustaceans, and jellyfish (Bjorndal, 1997). Older juveniles and adults are more specialized, feeding primarily on sponges, which compose as much as 95 percent of their diet in some locations, although the diet of adult hawksbills in the Indo-Pacific region includes other invertebrates and algae (Meylan, 1988; Witzell, 1983). The shape of their mouth allows hawksbills to reach into holes and crevices of coral reefs to find sponges and other invertebrates.

Predators of hawksbills vary according to turtle location and size. Land predators that eat eggs and hatchlings include ants, crabs, birds, and mammals such as dogs, raccoons, and feral pigs. Aquatic predators, mostly fish and sharks, impact hatchlings most heavily in nearshore areas. Sharks are also the primary predators of juvenile and adult turtles (Stancyk, 1982).

3.8.2.2.3 Loggerhead Sea Turtle (*Caretta caretta*)

Loggerhead sea turtles are one of the larger species of turtle, named for their large blocky heads that support powerful jaws used to feed on hard-shelled prey. The loggerhead is found in temperate to tropical regions of the Atlantic, Pacific, and Indian Oceans and in the Mediterranean Sea.

Status and Management

The loggerhead was the subject of a complete stock analysis conducted to identify DPSs within the global population (Conant et al., 2009). Three DPSs occur in the Pacific Ocean: North Pacific, South Pacific, and Southeast Indo-Pacific Ocean. The Hawaii region occurs within the range of the North Pacific DPS. Genetic data (Bowen et al., 1995; Resendiz et al., 1998) and tagging data (Conant et al., 2009) indicate that nesting females of the South Pacific and Southeast Indo-Pacific Ocean DPSs rarely, if ever, are found in northern Pacific Ocean waters. North Pacific Ocean loggerheads nest exclusively in Japan. Based on a review of census data collected from most of the Japanese beaches from the 1950s through the 1990s, Kamezaki et al. (2003) concluded that the annual loggerhead nesting population in Japan declined 50 to

90 percent in recent decades. Loggerheads are declining and at risk of extirpation from the northern Pacific Ocean. This drop in numbers is primarily the result of fishery by-catch from the coastal pound net fisheries off Japan, coastal fisheries that affect juvenile foraging populations off Baja California, and undescribed fisheries that likely affect loggerheads in the South China Sea and the northern Pacific Ocean (NMFS and USFWS, 2007d). The North Pacific Ocean DPS is listed under the ESA as endangered because of the significance of threats to the species, small current nesting population, and estimated historical decline in the nesting population. Critical habitat is currently not designated for Pacific Ocean loggerheads.

Habitat and Geographic Range

The loggerhead turtle is found in habitats ranging from coastal estuaries to the open ocean (Dodd, 1988). Most of the loggerheads observed in the eastern North Pacific Ocean are believed to come from beaches in Japan where the nesting season is late May to August (NMFS and USFWS, 1998c). Migratory routes can be coastal or can involve crossing deep ocean waters (Schroeder et al., 2003). The species can be found hundreds of kilometers out to sea, as well as in inshore areas, such as bays, lagoons, salt marshes, creeks, ship channels, and the mouths of large rivers. Coral reefs, rocky places, and shipwrecks are often used as feeding areas. The nearshore zone provides crucial foraging habitat, as well as internesting and overwintering habitat.

Loggerheads typically nest on beaches close to reef formations and adjacent to warm currents (Dodd, 1988). They prefer nesting beaches facing the open ocean or along narrow bays (Conant et al., 2009). Nesting beaches tend to be wide and sandy, backed by low dunes and fronted by a flat sandy approach from the water (Miller et al., 2003). Nests are typically laid between the high tide line and the dune front (Hailman and Elowson, 1992).

Pacific Ocean loggerheads appear to use the entire North Pacific Ocean during development. There is substantial evidence that the North Pacific Ocean stock makes two transoceanic crossings. The first crossing (west to east) is made immediately after they hatch from the nesting beach in Japan, while the second (east to west) is made when they reach either the late juvenile or adult life stage at the foraging grounds in Mexico. Offshore, juvenile loggerheads forage in or migrate through the North Pacific Subtropical Gyre as they move between North American developmental habitats and nesting beaches in Japan. The highest densities of loggerheads can be found just north of Hawaii in the North Pacific Transition Zone (Polovina et al., 2000).

The North Pacific Transition Zone is defined by convergence zones of high productivity that stretch across the entire northern Pacific Ocean from Japan to California (Polovina et al., 2001). Within this gyre, the Kuroshio Extension Bifurcation Region is an important habitat for juvenile loggerheads (Polovina et al., 2006). These turtles, whose oceanic phase lasts a decade or more, have been tracked swimming against the prevailing current, apparently to remain in the areas of highest productivity. Juvenile loggerheads originating from nesting beaches in Japan migrate through the North Pacific Transition Zone en route to important foraging habitats in Baja California (Bowen et al., 1995).

NMFS and USFWS (1998c) listed four sighting records of this species for the Hawaiian Islands, all juveniles. A single male loggerhead turtle has also been reported to visit Lehua Channel and Keamano Bay (located off the northern coast of Niihau) every June through July (DoN, 2001, 2002). Only one loggerhead stranding has been recorded in the Hawaiian Islands since 1982 (NMFS, 2004). While incidental catches of loggerheads in the Hawaii-based longline fishery indicate that they use these waters during migrations and development (Polovina et al., 2000), their occurrence in the offshore waters of Hawaii is believed to be rare.

Diving profiles in open ocean and nearshore habitats appear to be based on the location of the food source, with turtles foraging in the nearshore habitat diving to the seafloor (average depth 165 to 330 feet) (50 to 101 meters) and those in the open ocean habitat diving exclusively in the 0- to 80-foot (0- to

24-meter) depth range (Hatase et al., 2007). Dive duration increased in warmer waters. The average foraging dive duration was 25 minutes, although night resting dives to depths of 45 feet (14 meters) longer than 300 minutes were recorded. Resting appears to be the main function of night dives (Hatase et al., 2007).

A diving study of two longline-caught loggerheads in the central North Pacific Ocean showed that the turtles spent about 40 percent of their time in the top 3 feet (0.9 meter), 70 percent of the dives were no deeper than 15 feet (4.6 meters), and virtually all of their time was spent in water shallower than 330 feet (101 meters) (Polovina et al., 2002).

Population and Abundance

The global population of loggerhead turtles is estimated at 43,320 to 44,560 nesting females (NMFS and USFWS, 2007d). The largest nesting populations occur in the subtropics on the western rims of the Atlantic and Indian Oceans. The largest nesting aggregation in the Pacific Ocean occurs in southern Japan, where fewer than 1,000 females breed annually (Kamezaki et al., 2003). Seminoff et al. (2004) carried out aerial surveys for loggerhead turtles along the Pacific coast of the Baja California Peninsula, Mexico, an area long thought to be critical habitat for juveniles. Surveys were carried out from September to October 2005 and encompassed nearly 7,000 kilometers of track-line with offshore extents to 170 kilometers. More than 400 turtles were sighted. Loggerheads were the most prevalent (77 percent of all sightings). Olive ridleys (12 percent), green turtles (7 percent), and leatherback turtles (less than 1 percent) were also sighted.

Females lay three to five clutches of eggs, and sometimes lay additional clutches, during a single nesting season (NMFS and USFWS, 2007d). Mean clutch size is approximately 100 to 130 eggs (Dodd, 1988). The temperature of a viable nest ranges between 79 °F and 90 °F (26 °C and 32 °C). Eggs incubate for approximately two months before they hatch (Mrosovsky, 1980). As with all sea turtles, an incubation temperature near the upper end of the viable range (90 °F [32 °C]) produces all females, and an incubation temperature near the lower end (79 °F [26 °C]) produces all male hatchlings (Mrosovsky, 1980).

Hatchlings travel to oceanic habitats and often are found in seaweed drift lines (Carr, 1986, 1987; Witherington and Hirama, 2006). Loggerheads spend the first 7 to 11.5 years of their lives in the open ocean (Bolten, 2003). At about 14 years old, some juveniles move to nearshore habitats close to their birth area, while others remain in the oceanic habitat or move back and forth between the two (Musick and Limpus, 1997). Turtles may use the same nearshore developmental habitat all through maturation or may move among different areas, finally settling in an adult foraging habitat. Loggerheads reach sexual maturity at around 35 years of age and move from subadult to adult coastal foraging habitats (Godley et al., 2003; Musick and Limpus, 1997). Data from Japan (Hatase et al., 2002), Cape Verde (Hawkes et al., 2006), and Florida (Reich et al., 2007) indicate that at least some of the adult population forages in the open ocean.

Predator and Prey Interactions

In both open ocean and nearshore habitats, loggerheads are primarily carnivorous, although they also consume some algae (Bjorndal, 1997; Dodd, 1988). Both juveniles and adults forage in coastal habitats, where they feed primarily on the bottom, although they also capture prey throughout the water column (Bjorndal, 2003). Adult loggerheads feed on a variety of bottom-dwelling animals, such as crabs, shrimp, sea urchins, sponges, and fish. They have powerful jaws that enable them to feed on hard-shelled prey, such as whelks and conch. During migration through the open sea, they eat jellyfish, molluscs, flyingfish, and squid.

Polovina et al. (2006) found that juvenile loggerheads in the western North Pacific Ocean at times swim against weak prevailing currents because they are attracted to areas of high productivity. Similar observations have been made in the Atlantic (Hawkes et al., 2006). These results suggest that the location of currents and associated frontal eddies is important to the loggerhead's foraging during its open ocean stage (McClellan and Read, 2007).

3.8.2.2.4 Olive Ridley Sea Turtle (*Lepidochelys olivacea*)

The olive ridley is a relatively small, hard-shelled sea turtle named for its olive green top shell. The olive ridley is known as an open ocean species but can also be found in coastal areas. They are found in tropical waters of the south Atlantic, Indian, and Pacific Oceans. While the olive ridley is the most abundant sea turtle species in the world (NMFS and USFWS, 1998d), with some of the largest nesting beaches occurring along the Pacific coast of Central America, few data about its occurrence in the study area are available.

Status and Management

The Mexican Pacific Ocean coast nesting population has been classified as endangered because of extensive overharvesting of olive ridley turtles in Mexico, which caused a severe population decline. All other populations are listed under the ESA as threatened. Before this commercial exploitation, the olive ridley was highly abundant in the eastern tropical Pacific Ocean, probably outnumbering all other sea turtle species combined (NMFS and USFWS, 1998d). Today, this population appears to be stable or increasing (NMFS and USFWS, 2007e), although the decline of the species continues at several important nesting beaches in Central America. Critical habitat has not been designated for the olive ridley.

Available information indicates that the population could be separated by ocean basins under the DPS policy (NMFS and USFWS, 2007e). Based on genetic data, the worldwide olive ridley population is composed of four main lineages: east India, Indo-Western Pacific, Atlantic, and eastern Pacific Ocean (Bowen et al., 1998; Shankar et al., 2004).

Habitat and Geographic Range

Most olive ridley turtles lead a primarily open ocean existence (NMFS and USFWS, 1998d). The turtles disperse outside of the breeding season, but little is known of their foraging habitats or migratory behavior. Neither males nor females migrate to one specific foraging area but tend to roam and occupy a series of feeding areas in the open ocean (Plotkin et al., 1994). The olive ridley has a large range in tropical and subtropical regions in the Pacific Ocean and is generally found between 40° N and 40° S. Both adult and juvenile olive ridley turtles typically inhabit offshore waters, foraging from the surface to a depth of 490 feet (149.4 meters) (NMFS and USFWS, 1998e).

The secondmost important nesting area for olive ridley turtles, globally, occurs in the eastern Pacific Ocean, along the western coast of southern Mexico and northern Costa Rica, with stragglers nesting as far north as southern Baja California (Fritts et al., 1982) and as far south as Peru (Brown and Brown, 1995). Individuals occasionally occur in waters as far north as California and as far south as Peru, spending most of their life in the oceanic zone (NMFS and USFWS, 2007e).

Data collected during tuna fishing cruises from Baja California to Ecuador and from the Pacific coast to almost 150° W indicated that the two most important areas in the Pacific Ocean for the olive ridley turtles are the Central American coast and the nursery and feeding area off Colombia and Ecuador. In these areas, both adults (mostly females) and juveniles are often seen (NMFS and USFWS, 1998d).

In the open ocean of the eastern Pacific Ocean, olive ridley turtles are often seen near flotsam (floating debris), possibly feeding on associated fish and invertebrates (Pitman, 1992). Although no estimates are available, the highest densities of olive ridley turtles are likely found just south of Hawaii, as their distribution in the central Pacific Ocean is primarily tropical (Polovina et al., 2004). About 18 percent of the sea turtles incidentally caught by the Hawaii-based longline fishery, which operates throughout this region, are olive ridley turtles (NMFS and USFWS, 1998d; NMFS, 2011c). Arenas and Hall (1992) found that 75 percent of sea turtles associated with floating objects in the eastern tropical Pacific Ocean were olive ridley turtles, which were present in 15 percent of the observations; this finding suggests that flotsam may provide the turtles with food, shelter, and orientation cues.

An estimated 31 olive ridley turtle strandings were recorded in the Hawaiian Islands between 1982 and 2003 (Chaloupka et al., 2008a).Few sightings have been recorded in the nearshore waters of the Main Hawaiian Islands and Nihoa. Available information suggests that olive ridley turtles traverse through the oceanic waters surrounding the Hawaiian Islands during foraging and developmental migrations. Genetic analysis of olive ridley turtles captured in the Hawaii-based longline fishery showed that 67 percent originated from the eastern Pacific Ocean (Mexico and Costa Rica), and 33 percent of the turtles were from the Indian and western Pacific Ocean rookeries (Polovina et al., 2004). These turtles were captured in deep, offshore waters of the Hawaiian Islands, primarily during spring and summer. Based on the oceanic habitat preferences of this species throughout the Pacific Ocean, this species is likely more prevalent year-round in waters off the Hawaiian Islands beyond the 330-foot (100-meter) isobath, with only rare occurrences inside this isobath.

The Pacific Ocean population migrates throughout the Pacific Ocean, from their nesting grounds in Mexico and Central America to the North Pacific Ocean (NMFS and USFWS, 2007e). The post-nesting migration routes of olive ridley turtles tracked via satellite from Costa Rica traversed thousands of kilometers of deep oceanic waters from Mexico to Peru and more than 1,865 miles (3,000 kilometers) out into the central Pacific Ocean (Plotkin et al., 1994). Tagged turtles nesting in Costa Rica were recovered as far south as Peru, as far north as Oaxaca, Mexico, and offshore to a distance of 1,080 NM (NMFS and USFWS, 1998d).

Groups of 100 or more turtles have been observed as far offshore as 120° W at about 1,620 NM from shore (Arenas and Hall, 1992). Sightings of large groups of olive ridley turtles at sea reported by Oliver in 1946 (NMFS and USFWS, 1998d) may indicate that turtles travel in large flotillas between nesting beaches and feeding areas (Márquez M., 1990). Specific post-breeding migratory pathways to feeding areas do not appear to exist, although olive ridley turtles swim hundreds to thousands of kilometers over vast oceanic areas.

Olive ridley turtles can dive and feed at considerable depths (260 to 1,000 feet) (79 to 305 meters) (NMFS and USFWS, 1998d), although only about 10 percent of their time is spent at depths greater than 330 feet (100 meters) (Eckert et al., 1986; Polovina et al., 2002). In the eastern tropical Pacific Ocean, at least 25 percent of their total dive time is spent between 65 and 330 feet (20 and 101 meters) (Parker et al., 2003). In the North Pacific Ocean, two olive ridley turtles tagged with satellite-linked depth recorders spent about 20 percent of their time in the top meter and about 10 percent of their time deeper than 330 feet (100 meters); a daily maximum depth exceeded 490 feet (149 meters) at least once in 20 percent of the days, with one dive recorded at 835 feet (255 meters). While olive ridley turtles are known to forage to great depths, 70 percent of the dives from this study were no deeper than 15 feet (4.6 meters) (Polovina et al., 2002).

Population and Abundance

The olive ridley is the most abundant sea turtle in the world (Pritchard, 1997) and the most abundant sea turtle in the open ocean waters of the eastern tropical Pacific Ocean (Pitman, 1990). They nest in nearly 60 countries worldwide, with an estimated 800,000 females nesting annually (NMFS, 2010d). This is a dramatic decrease over the past 50 years, where the population from the five Mexican Pacific Ocean beaches was previously estimated at 10 million adults (Cliffton et al., 1995). The number of olive ridley turtles occurring in U.S. territorial waters is believed to be small (NMFS and USFWS, 1998d). At-sea abundance surveys conducted along the Mexican and Central American coasts between 1992 and 2006 provided an estimate of 1.39 million turtles in the region, which was consistent with the increases seen on the eastern Pacific Ocean nesting beaches between 1997 and 2006 (NMFS and USFWS, 2007e).

Little is known about the age and sex distribution, growth, birth and death rates, or immigration and emigration of olive ridley turtles. Hatchling survivorship is unknown, although presumably, as with other turtles, many die during the early life stages. Both adults and juveniles occur in open sea habitats, though sightings are relatively rare. The median age to sexual maturity is 13 years, with a range of 10 to 18 years (Zug et al., 2006).

Olive ridley turtles use two types of nesting strategies. In 18 locations around the world, they conduct annual synchronized nesting, a phenomenon known as an “arribada” (NMFS and USFWS, 1998d), where hundreds to tens of thousands of olive ridley turtles emerge over a period of a few days. In the eastern Pacific Ocean, arribada nesting occurs throughout the year, although it peaks from September to December (Fretey, 2001). Arribadas occur on several beaches in Mexico, Nicaragua, Costa Rica, and Panama. Olive ridley turtles also lay solitary nests throughout the world, although little attention has been given to this nesting strategy because of the dominant interest in arribada research (NMFS and USFWS, 2007e). Solitary nesting occurs in at least 46 countries throughout the world (Kalb and Owens, 1994), including along nearly the entire Pacific Ocean coast of Mexico, with the greatest concentrations closer to arribada beaches. In Hawaii, olive ridleys have been known to nest sporadically on Maui, at U.S. Marine Corps Base Hawaii on Oahu in 2009, and on the Ka’u coast on the Island of Hawaii in 2010.

Females and males begin to group in “reproductive patches” near their nesting beaches two months before the nesting season, and most mate near the nesting beaches, although mating has been observed throughout the year as far as 565 miles (909 kilometers) from the nearest mainland (Pitman, 1990). Arribadas usually last from three to seven nights, and due to the sheer number of nesters, later arrivers disturb and dig up many existing nests, lowering overall survivorship during this phase (NMFS and USFWS, 1998d). A typical female produces two clutches per nesting season, averaging 105 eggs at 15- to 17-day intervals for lone nesters and 28-day intervals for mass nesters (NMFS and USFWS, 1998d; Plotkin et al., 1994). Studies show that females that nested in arribadas remain within 3 miles (4.8 kilometers) of the beach most of the time during the internesting period (Kalb and Owens, 1994). Incubation time from egg deposition to hatching is approximately 55 days (Pritchard and Plotkin, 1995). Hatchlings emerge weighing less than 1 ounce (less than 28 grams) and measuring about 1.5 inches (3.8 centimeters).

Predator and Prey Interactions

Olive ridley sea turtles are primarily carnivorous. They consume a variety of prey in the water column and on the seafloor, including snails, clams, tunicates, fish, fish eggs, crabs, oysters, sea urchins, shrimp, and jellyfish (Fritts, 1981; Márquez M., 1990; Mortimer, 1995; Polovina et al., 2004). Olive ridleys are subject to predation by the same predators as other sea turtles, such as sharks on adult olive ridleys, fish and sharks on hatchlings, and various land predators on hatchlings (e.g., ants, crabs, birds, and mammals) (NMFS and USFWS, 1998d).

3.8.2.2.5 Leatherback Sea Turtle (*Dermochelys coriacea*)

Leatherback turtles have several unique characteristics. They are distinguished from other sea turtles by their leathery shell, and they are the largest species of sea turtle; adults can reach 6.5 feet (2 meters) in length (NMFS and USFWS, 1992). Leatherbacks are also the most migratory sea turtles and are able to tolerate colder water than other species (Hughes et al., 1998; James and Mrosovsky, 2004). Leatherbacks are the deepest-diving sea turtle (Hays, Houghton, et al., 2004). They are found in tropical to temperate regions of the Atlantic, Indian, and Pacific Oceans. Leatherbacks are known as an open ocean species but can also rarely be found in coastal waters within the study area.

Status and Management

In the Pacific Ocean, NMFS has identified two subpopulations: western and eastern Pacific leatherbacks. All leatherbacks are classified as endangered under the ESA. Western Pacific leatherbacks nest in the Indo-Pacific and migrate back to feeding areas off the Pacific coast of North America. Eastern Pacific leatherbacks nest along the Pacific coast of the Americas in Mexico and Costa Rica. Most stocks in the Pacific Ocean are faring poorly; western Pacific leatherbacks have declined by more than 80 percent, while eastern Pacific leatherbacks have declined by over 97 percent. In contrast, western Atlantic and South African populations are generally stable or increasing (Turtle Expert Working Group, 2007).

A total of 203 nesting beaches from 46 countries around the world have been identified (Dutton, 2006). The leatherback sea turtle has been reported to nest on the Lanai in the past. Although these data are beginning to form a global perspective, unidentified sites likely exist, and incomplete or no data are available for many other sites. The eastern Pacific subpopulation nests between Mexico and Ecuador, and the western Pacific subpopulation nests in numerous countries, including Australia, Fiji, Indonesia, and China. Leatherbacks have been in decline in all major Pacific basin rookeries (nesting areas/groups) (NMFS and USFWS, 2007b; Turtle Expert Working Group, 2007) for at least the last two decades (Gilman, 2008; Sarti-Martinez et al., 1996; Spotila et al., 1996; Spotila et al., 2000). Causes for this decline include the nearly complete harvest of eggs and high levels of mortality during the 1980s, primarily in the high seas driftnet fishery, which is now banned (Chaloupka et al., 2004; Eckert and Sarti-Martinez, 1997; Gilman, 2008; Sarti-Martinez et al., 1996). With only four major rookeries remaining in the western Pacific Ocean and two in the eastern Pacific Ocean, the Pacific leatherback is at an extremely high risk of extinction (Gilman, 2008).

Habitat and Geographic Range

The leatherback turtle is the most widely distributed of all sea turtles, found from tropical to subpolar oceans, and nests on tropical and occasionally subtropical beaches (Gilman, 2008; Myers and Hays, 2006; NMFS and USFWS, 1992). Found from 71° N to 47° S, it has the most extensive range of any adult turtle (Eckert, 1995). Adult leatherback turtles forage in temperate and subpolar regions in all oceans and migrate to tropical nesting beaches between 30° N and 20° S. Leatherbacks have a wide nesting distribution, primarily on isolated mainland beaches in tropical and temperate oceans (NMFS and USFWS, 1992) and to a lesser degree on some islands.

Hatchling leatherbacks head out to the open ocean, but little is known about their distribution for the first four years (Musick and Limpus, 1997). Sightings of turtles smaller than 55 inches (140 centimeters) indicate that some juveniles remain in coastal waters in some areas (Eckert et al., 1999).

Few quantitative data are available concerning the seasonality, abundance, or distribution of leatherbacks in the central northern Pacific Ocean. Satellite tracking studies and occasional incidental captures of the species in the Hawaii-based longline fishery indicate that deep ocean waters are the preferred habitats of leatherback turtles in the central Pacific Ocean (NMFS and USFWS, 2007b). The primary migration corridors for leatherbacks are across the North Pacific Subtropical Gyre, with the eastward migration route possibly to the north of the westward migration (Dutton, unpublished data).

The primary data available for leatherbacks in the North Pacific Transition Zone come from longline fishing by-catch reports, as well as several satellite telemetry data sets (Benson et al., 2007). Leatherbacks from both eastern and western Pacific Ocean nesting populations migrate to northern Pacific Ocean foraging grounds, where longline fisheries operate (Dutton et al., 1998). Leatherbacks from nesting beaches in the Indo-Pacific region have been tracked migrating thousands of kilometers through the North Pacific Transition Zone to summer foraging grounds off the coast of northern California (Benson et al., 2007). Based on the genetic sampling of 18 leatherback turtles caught in the Hawaiian longline fishery, about 94 percent originated from western Pacific Ocean nesting beaches (NMFS and USFWS, 2007b). The remaining 6 percent of the leatherback turtles found in the open ocean waters north and south of the Hawaiian Islands represent nesting groups from the eastern tropical Pacific Ocean.

Leatherback turtles are regularly sighted by fishermen in offshore waters surrounding the Hawaiian Islands, generally beyond the 3,800-foot (1,158-meter) contour and especially at the southeastern end of the island chain and off the northern coast of Oahu (Balazs, 1995). Leatherbacks encountered in these waters, including those caught accidentally in fishing operations, may be migrating through the Insular Pacific-Hawaiian Large Marine Ecosystem (NMFS and USFWS, 1998e). Sightings and reported interactions with the Hawaii longline fishery commonly occur around seamount habitats above the Northwestern Hawaiian Islands (from 35° N to 45° N and 175° W to 180° W) (Skillman and Balazs, 1992; Skillman and Kleiber, 1998).

The leatherback turtle occurs within the entire Insular Pacific-Hawaiian Large Marine Ecosystem beyond the 330-foot (100-meter) isobath; occurrence is rare inside this isobath. Incidental captures of leatherbacks have also occurred at several offshore locations around the Main Hawaiian Islands (McCracken, 2000). Although leatherback by-catches are common off the island chain, leatherback-stranding events on Hawaiian beaches are uncommon. Since 1982, only five leatherbacks have stranded in the Hawaiian Islands (Chaloupka et al., 2008a). Leatherbacks were not sighted during aerial surveys conducted over waters lying close to the Hawaiian shoreline. Leatherbacks were also not sighted during NMFS shipboard surveys; their deep diving capabilities and long submergence times reduce the probability that observers could spot them during marine surveys. One leatherback turtle was observed along the Hawaiian shoreline during monitoring surveys in 2006 (Rivers, 2011).

The leatherback is the most oceanic and wide-ranging of sea turtles, undertaking extensive migrations along distinct depth contours for hundreds to thousands of kilometers (Hughes et al., 1998; Morreale et al., 1996). After they nest, female leatherbacks migrate from tropical waters to more temperate latitudes that support high densities of jellyfish in the summer. Late juvenile and adult leatherback turtles are known to range from mid-ocean to the continental shelf and nearshore waters (Frazier, 2001), foraging in coastal areas in temperate waters and offshore areas in tropical waters (Frazier, 2001). Their movements appear to be linked to the seasonal availability of their prey and the requirements of their reproductive cycle (Davenport and Balazs, 1991). Trans-Pacific Ocean migrations have been reported, including a 6,385-mile (10,276-kilometer) migration from a nesting beach in Papua New Guinea to foraging grounds off the coast of Oregon (Benson et al., 2007).

Eighty percent of the leatherback's time at sea is spent diving (Fossette et al., 2007). The leatherback is the deepest diving sea turtle, with recorded depths of at least 4,035 feet (1,230 meters) (Hays, Metcalfe, et al., 2004), although most dives are much shallower, usually less than 655 feet (200 meters) (Hays, Houghton et al., 2004; Sale et al., 2006). Leatherbacks spend most of their time in the upper 215 feet (66 meters) of the water column (Jonsen et al., 2007). Diving is influenced by many factors, including water temperature and local availability and vertical distribution of food resources, resulting in variations in dive times and distances (James et al., 2006; Sale et al., 2006).

The dive time limit for the leatherback is estimated at between 33 and 67 minutes (Hays, Houghton, et al., 2004; Hays, Metcalfe, et al., 2004; Southwood et al., 1999), with typical durations of 6.9 to 14.5 minutes (Eckert et al., 1996). During migrations or long-distance movements, leatherbacks travel within 15 feet (4.8 meters) of the surface (Eckert, 2002), making scouting dives to sample prey density and feed on whatever is available (James et al., 2006; Jonsen et al., 2007).

In warm waters, leatherbacks dive deeper and longer (James et al., 2005), spending only short periods at the surface between dives (Eckert et al., 1986). While diving in colder waters, sometimes just above freezing, leatherbacks make shorter dives and spend up to 50 percent of their time at or near the surface (James et al., 2006; Jonsen et al., 2007).

Population and Abundance

The major nesting populations of the Eastern Pacific leatherbacks occur in Mexico, Costa Rica, Panama, Colombia, Ecuador, and Nicaragua (Chaloupka et al., 2004; Dutton et al., 1999; Eckert and Sarti-Martinez, 1997; Márquez M., 1990; Sarti-Martinez et al., 1996; Spotila et al., 1996), with the largest ones in Mexico and Costa Rica. There are 28 known nesting sites for the Western Pacific population, with an estimated 5,000 to 9,100 leatherback nests annually across the western tropical Pacific Ocean, from

Australia and Melanesia (Papua New Guinea, Solomon Islands, Fiji, and Vanuatu) to Indonesia, Thailand, and China (Chaloupka et al., 2004; Chua, 1988; Dutton, 2006; Hirth et al., 1993; Suarez et al., 2000).

Leatherback hatchlings are approximately 2 to 3 inches (5 to 7.6 centimeters) long and weigh approximately 1.4 to 1.8 ounces (40 to 51 grams). As with other sea turtle species, limited information is available on the open ocean habitats used by hatchling and early juvenile leatherbacks (NMFS and USFWS, 1992). Leatherbacks whose shell length is less than 40 inches (102 centimeters) have only been sighted in waters at least 79°F (26 °C), restricting their habitat primarily to the tropics (Eckert, 2002; Sarti-Martinez, 2000). Other than a general association with warm waters, the distribution of hatchling and early juvenile leatherbacks is not known. Upwelling areas, such as equatorial convergence zones, are nursery grounds for hatchling and early juvenile leatherbacks, because these areas provide a good supply of prey (Musick and Limpus, 1997). Individuals with a curved shell length of less than 57 inches (145 centimeters) are considered to be juveniles (Eckert, 2002; NMFS, 2001).

Leatherbacks are likely the fastest developing of all sea turtle species, reaching adulthood at 13 to 14 years (range 2 to 22 years) (Turtle Expert Working Group, 2007; Zug and Parham, 1996), and can live to 30 years or more (Sarti-Martinez, 2000). Throughout their lives, leatherbacks are essentially oceanic, yet they enter coastal waters to forage and reproduce (NMFS and USFWS, 1992). The species is not typically associated with coral reefs but is occasionally encountered in deep ocean waters near prominent island chains, such as deep waters off the Hawaiian Island chain (Eckert, 1993). There is evidence that leatherbacks are associated with oceanic front systems, such as shelf breaks and the edges of oceanic gyre systems, where their prey is concentrated (Eckert, 1993).

The leatherback’s unique anatomy and metabolism, compared with all other turtle species (Bradshaw et al., 2007; Goff and Stenson, 1988; Greer et al., 1973; Mrosovsky and Pritchard, 1971; Neill and Stevens, 1974; Paladino et al., 1990), allows them to maintain a core body temperature higher than that of the surrounding water, thereby allowing them to tolerate colder waters (Frair et al., 1972; James and Mrosovsky, 2004). As juveniles grow, this ability is enhanced, allowing leatherbacks to expand their ranges into the cooler waters (Eckert, 2002).

Nesting leatherbacks prefer wide sandy beaches backed with vegetation (Eckert, 1987; Hirth and Ogren, 1987). In the water, they prefer habitat characterized by steep drop-offs or mud banks without coral or rock formations (Turtle Expert Working Group, 2007). For both the western and eastern Pacific subpopulations, the nesting season extends from October through March, with a peak in December. The Jamursba-Medi (Papua) stock is an exception, nesting from April to October, with a peak in August (Chaloupka et al., 2004). Typical clutches are 50 to more than 150 eggs, with the incubation period lasting around 65 days. Females lay an average of 5 to 7 clutches in a single season (with a maximum of 11) with intervals of 8 to 10 days or longer (NMFS and USFWS, 1992). Females remain in the general vicinity of the nesting habitat for their breeding period, which can last up to four months (Eckert et al., 1989b; Keinath and Musick, 1993), although they may nest on several islands in a chain during a single nesting season (Pritchard, 1982). Mating is thought to occur before or during the migration from temperate to tropical waters (Eckert and Eckert, 1988).

Predator and Prey Interactions

Leatherbacks lack the crushing and chewing plates characteristic of other sea turtle species that feed on hard-bodied prey (NMFS, 2010c). Instead, they have pointed tooth-like cusps and sharp-edged jaws that are used for consuming soft-bodied prey such as jellyfish and salps (Bjorndal, 1997; Grant and Ferrell, 1993; James and Herman, 2001; NMFS and USFWS, 1992; Salmon et al., 2004). Leatherbacks feed at the surface and at depth, diving to 4,035 feet (1,240 meters) (Davenport, 1988; Eckert et al., 1989a; Eisenberg and Frazier, 1983; Grant and Ferrell, 1993; Hays, Houghton, et al., 2004; James et al., 2005; Salmon et al., 2004). Leatherbacks in the Caribbean may synchronize their diving patterns with the daily vertical migration of a deep-water ecosystem of fishes, crustaceans, gelatinous salps, and siphonophores, known as the deep scattering layer, which moves toward the surface of the ocean at dusk and descends at sunrise

(Eckert et al., 1989a; Eckert et al., 1986). A similar vertical migration of small fish and crustacean species has been studied in the Insular Pacific-Hawaiian Large Marine Ecosystem, which migrates from approximately 1,300 to 2,300 feet (396 to 701 meters) during the day to near the surface at night (Benoit-Bird et al., 2001). It is unknown whether this type of foraging is widespread for leatherbacks (Eckert et al., 1989a). Leatherbacks on known feeding grounds have been observed foraging on jellyfish at the surface (Grant and Ferrell, 1993; James and Herman, 2001; Starbird et al., 1993). Leatherbacks are subject to predation by the same predators as other sea turtles, such as sharks, certain fish preying on hatchlings, and various land predators preying on hatchlings (e.g., ants, crabs, birds, and mammals) (NMFS and USFWS, 2007c).

3.8.2.3 Marine Fish

A wide variety of marine fish species occur in the vicinity of the BSURE area. Distribution and occurrence is primarily influenced by the presence or absence of a species' preferred habitat and by physical and biological factors such as salinity, temperature, dissolved oxygen, population dynamics, predator and prey interactions, seasonal movements, reproduction and life cycles, and recruitment success. Another major influence of species distribution is the location of highly productive regions, such as frontal zones. These areas may concentrate various prey species and their predators.

Some species, such as large sharks, tuna, and billfishes, range across thousands of square miles; others, such as many reef fishes, have small home ranges and restricted distributions. The movements of some open-ocean species may never overlap with coastal fishes that spend their adult lives within several hundred feet (a few hundred meters) of the shore. Even within a single fish species, the distribution and specific habitats in which an individual occurs may be influenced by its developmental stage, size, sex, reproductive condition, and other factors.

Approximately 566 species of reef and shore fishes are known to occur in the insular Hawaiian area. Hawaii's hydrographical isolation results in numerous species that are found only in the Hawaiian Islands. In contrast, migratory open ocean fishes in the region are able to move across the great distances that separate the Hawaiian Islands from other islands or continents in the Pacific.

Representative marine fish taxa potentially occurring in or near the study area are shown in Table 3.8-5. No species currently protected under the ESA occur in the BSURE area. Federally managed fish species are described in Section 3.8.3.2.4, *Essential Fish Habitat*.

Table 3.8-5. Fish Taxa in the Hawaiian Islands Region

Representative Taxa	Major Representative Groups
Orders Myxiniformes and Petromyzontiformes	Jawless fishes
Class Chondrichthyes	Sharks, rays, and chaemeras
Orders Anguilliformes and Elopiformes	Eels and bonefishes
Orders Argentiniformes and Osmeriformes	Smelts
Orders Stomiiformes and Myctophiformes	Dragonfishes and lanternfishes
Order Aulopiformes	Greeneyes, lizardfishes, lancetfishes, and telescopefishes
Orders Gadiformes and Ophidiiformes	Cods and cusk-eels
Orders Batrachoidiformes and Lophiiformes	Toadfishes and anglerfishes
Orders Mugiliformes, Atheriniformes, Beloniformes, and Cyprinodontiformes	Mullets, silversides, needlefish, and killifish
Orders Lampridiformes, Beryciformes, and Zeiformes	Oarfishes, squirrelfishes, and dories
Order Gasterosteiformes	Pipefishes and seahorses
Order Scorpaeniformes	Scorpionfishes

Table 3.8-5. Fish Taxa in the Hawaiian Islands Region (Cont'd)

Representative Taxa	Major Representative Groups
Families Sciaenidae and Lutjanidae	Croakers, drums, and snappers
Family Serranidae	Groupers and seabasses
Families Labridae, Scaridae, and Pomacentridae	Wrasses, parrotfish, and damselfishes
Suborders Gobioidei, Blennioidei, and Acanthuroidei	Gobies, blennies, and surgeonfishes
Families Carangidae, Scombridae, Xiphiidae, and Istiophoridae	Jacks, tunas, mackerels, and billfishes
Order Pleuronectiformes	Flounders
Order Tetraodontiformes	Triggerfish, puffers, and molas

Source: DoN, 2013

3.8.2.4 Essential Fish Habitat

The fisheries of the United States are managed within a framework of overlapping international, federal, state, interstate, and tribal authorities. Individual states and territories generally have jurisdiction over fisheries in marine waters within 3 NM of their coast (there are limited exceptions to this distance). Federal jurisdiction includes fisheries in marine waters inside the U.S. EEZ, which encompasses the area from (typically) 3 NM to 200 NM offshore of any U.S. coastline (NOAA, 1996).

The Magnuson Stevens Act (MSA) established jurisdiction over marine fishery resources within the U.S. EEZ. The Act mandated the formation of eight fishery management councils, which share authority with NMFS to manage and conserve fisheries in federal waters within their geographic jurisdiction. The councils are required to prepare and maintain an FMP for each managed fishery. The WPRFMC manages fisheries located within the Hawaiian Islands EEZ, in addition to several other U.S. territories and islands. Amendments contained in the Sustainable Fisheries Act of 1996 (Public Law 104-267) require the councils to identify EFH for each fishery covered under an FMP. EFH is defined as the waters and substrate necessary for spawning, breeding, or growth to maturity (16 USC 1802[10]). The term "fish" is defined as "finfish, mollusks, crustaceans, and all other forms of marine animals and plant life other than marine mammals and birds." In addition to EFH, the MSA also requires identification of habitat areas of particular concern (HAPCs), which are subsets of EFH that are rare, especially ecologically important, particularly susceptible to human-induced degradation, or located in environmentally stressed areas.

Similar to other regional councils, the WPRFMC historically managed fisheries through separate species-based FMPs, including the Bottomfish and Seamount Groundfish FMP, Crustaceans FMP, Precious Corals FMP, Coral Reef Ecosystems FMP, and Pelagic FMP. However, the WPRFMC has recently shifted toward an ecosystem-based approach, focusing fishery management activities on geographic areas that support various habitats and their associated species complexes rather than on individual species. Accordingly, the WPRFMC is in the process of replacing FMPs with Fishery Ecosystem Plans (FEPs). Five FEPs have been completed. FEPs associated with resources in the study area include the Hawaii Archipelago FEP (WPRFMC, 2009a) and the Pacific Pelagic Fisheries FEP (WPRFMC, 2009b).

Hawaii Archipelago Fishery Ecosystem Plan

The Hawaii Archipelago FEP does not establish new fishery management regulations but rather consolidates existing regulations contained in previous FMPs. The FEP identifies all demersal species (living on or near the seafloor) known to occur around the Hawaii Archipelago, designates them as one management unit, and incorporates all management provisions of the previous Bottomfish and Seamount Groundfish FMPs. The FEP also incorporates provisions of the previous Crustaceans, Precious Corals, and Coral Reef Ecosystems FMPs that are applicable to the area. EFH management units presently include bottomfish species (deep-slope and seamount species complexes consisting of snappers, groupers, jacks, pelagic armorhead, ratfish, and other similar taxa); crustaceans (spiny and slipper lobster species complex, deepwater shrimps, and Kona crab [*Ranina ranina*]); precious corals (non-reef-building corals occurring below the euphotic zone, historically important in the jewelry trade); and coral reef ecosystems (separate designations for currently harvested and potentially harvested coral taxa). EFH for management units covered by the Hawaii Archipelago FEP is summarized in Table 3.8-6.

Table 3.8-6. Essential Fish Habitat Designated in the Hawaii Archipelago Fishery Ecosystem Plan

Management Unit, Species Assemblage, or Species Complex	Designated Essential Fish Habitat	
	Adults and Juveniles	Eggs and Larvae
Bottomfish		
Deep-slope species complex	The water column and all bottom habitat extending from the shoreline to a depth of 400 meters (200 fathoms).	The water column extending from the shoreline to the outer boundary of the EEZ, to a depth of 400 meters.
Seamount species complex	Adult only: all waters and bottom habitat bounded by latitude 29° to 35° N and longitude 171° E to 179° W, between 80 and 600 meters deep.	Eggs, larvae, and juveniles: the epipelagic zone (0 to 200 meters water depth) of all waters bounded by latitude 29° to 35° N and longitude 171° E to 179° W.
Crustaceans		
Spiny lobster complex and Kona crab	Bottom habitat from the shoreline to a depth of 100 meters throughout the western Pacific region.	The water column from the shoreline to the outer limit of the EEZ, down to a depth of 150 meters throughout the western Pacific region.
Deepwater shrimp	Outer reef slopes between 550 and 700 meters deep.	The water column and associated outer reef slopes between 300 meters and 700 meters depth.
Precious corals	All life stages: all known precious coral beds of pink, gold, bamboo, and black coral. Currently known beds are located at Keahole Point, between Milolii and South Point, the Auau Channel, Makapuu, Kaena Point, the southern border of Kauai, Wespac bed, Brooks Bank, and 180 Fathom Bank.	
Coral reef ecosystems		
Currently harvested coral reef taxa		
Acanthuridae	All bottom habitat and the adjacent water column from 0 to 50 fathoms.	The water column from the shoreline to the outer boundary of the EEZ to a depth of 50 fathoms.
Balistidae	All bottom habitat and the adjacent water column from 0 to 50 fathoms.	The water column from the shoreline to the outer boundary of the EEZ to a depth of 50 fathoms.
Carangidae	All bottom habitat and the adjacent water column from 0 to 50 fathoms.	The water column from the shoreline to the outer boundary of the EEZ to a depth of 50 fathoms.
Carcharhinidae	All bottom habitat and the adjacent water column from 0 to 50 fathoms to the outer extent of the EEZ.	NA
Holocentridae	All rocky and coral areas and the adjacent water column from 0 to 50 fathoms.	The water column from the shoreline to the outer boundary of the EEZ to a depth of 50 fathoms.
Kuhliidae	All bottom habitat and the adjacent water column from 0 to 25 fathoms.	The water column from the shoreline to the outer boundary of the EEZ to a depth of 50 fathoms.

Table 3.8-6. Essential Fish Habitat Designated in the Hawaii Archipelago Fishery Ecosystem Plan (Cont'd)

Management Unit, Species Assemblage, or Species Complex	Designated Essential Fish Habitat	
	Adults and Juveniles	Eggs and Larvae
Kyphosidae	Adult only: all rocky and coral bottom habitat and the adjacent water column from 0 to 15 fathoms.	Eggs, larvae, and juveniles: the water column from the shoreline to the outer boundary of the EEZ to a depth of 50 fathoms.
Labridae	EFH for all life stages in the family Labridae is designated as the water column and all bottom habitat extending from the shoreline to the outer boundary of the EEZ to a depth of 50 fathoms.	
Mullidae	All rocky/coral and sand bottom habitat and adjacent water column from 0 to 50 fathoms.	The water column extending from the shoreline to the outer boundary of the EEZ to a depth of 50 fathoms.
Mugilidae	All sand and mud bottoms and the adjacent water column from 0 to 25 fathoms.	The water column from the shoreline to the outer limits of the EEZ to a depth of 50 fathoms.
Muraenidae	All rocky and coral areas and the adjacent water column from 0 to 50 fathoms.	The water column from the shoreline to the outer boundary of the EEZ to a depth of 50 fathoms.
Octopodidae	Adults, juveniles, and demersal eggs: all coral, rocky, and sand bottom areas from 0 to 50 fathoms.	Larvae only: the water column from the shoreline to the outer limits of the EEZ to a depth of 50 fathoms.
Polynemidae	All rocky/coral and sand bottom habitat and adjacent water column from 0 to 50 fathoms.	The water column from the shoreline to the outer boundary of the EEZ to a depth of 50 fathoms.
Priacanthidae	All rocky/coral and sand bottom habitat and adjacent water column from 0 to 50 fathoms.	The water column from the shoreline to the outer boundary of the EEZ to a depth of 50 fathoms.
Scaridae	All bottom habitat and the adjacent water column from 0 to 50 fathoms.	The water column from the shoreline to the outer limit of the EEZ to a depth of 50 fathoms.
Siganidae	All bottom habitat and the adjacent water column from 0 to 50 fathoms.	The water column from the shoreline to the outer boundary of the EEZ to a depth of 50 fathoms.
Sphyraenidae	EFH for all life stages in the family Sphyraenidae is designated as the water column from the shoreline to the outer boundary of the EEZ to a depth of 50 fathoms.	
Turbinidae	All bottom habitat and the adjacent water column from 0 to 50 fathoms.	The water column from the shoreline to the outer boundary of the EEZ to a depth of 50 fathoms.
Aquarium species/taxa	All coral, rubble, or other hard-bottom features and the adjacent water column from 0 to 50 fathoms.	All waters from 0 to 50 fathoms from the shoreline to the limits of the EEZ.
Potentially harvested coral reef taxa		
All potentially harvested species (thousands of species)	EFH for all life stages of potentially harvested coral reef taxa is designated as the water column and bottom habitat from the shoreline to the outer boundary of the EEZ, to a depth of 50 fathoms (91 feet).	

The WPRFMC has also designated HAPCs for managed species complexes. HAPCs associated with the Hawaii Archipelago FEP are identified in Table 3.8-7.

Table 3.8-7. Habitat Areas of Particular Concern Designated in the Hawaii Archipelago Fishery Ecosystem Plan

Species Complex	Habitat Areas of Particular Concern
Bottomfish and seamount groundfish (shallow-water and deep-water slope species only; no designation for seamount species)	(1) All slopes and escarpments between 40 and 280 meters (20 and 140 fathoms). (2) Three known areas of juvenile opakapaka habitat; two off Oahu and one off Molokai.
Crustaceans (lobster complexes and Kona crab only; no designation for shrimps)	All banks in the Northwestern Hawaiian Islands with summits less than or equal to 30 meters (15 fathoms) from the surface.
Precious corals	(1) Deep-water species: the Makapuu bed, Wespac bed, and Brooks Banks bed. (2) Shallow-water black coral species: the AuAu Channel.
Coral reef ecosystems	All no-take marine protected areas identified in the previous FMP, all Pacific remote islands, and numerous other marine protected areas, research sites, and coral reef habitats throughout the western Pacific.

Pacific Pelagic Fisheries Fishery Ecosystem Plan

The Pelagic Fisheries FEP provides for the management of targeted pelagic species, which are considered open-water species that are usually found away from the shore and are not associated with the seafloor. Pelagic species included in the FEP are found in tropical and temperate waters throughout the Pacific Ocean. Tunas and billfishes are the primary types of species addressed by the FEP, although other species such as mahi mahi, wahoo, and sharks are included as well. Distribution is variable and is affected by environmental conditions, ocean current patterns, and prey availability. Pelagic species may move considerable distances and cross numerous political boundaries. Therefore, the WPRFMC considers the FEP boundary to include all areas subject to pelagic fishing operations conducted by domestic (U.S.) vessels that are located (1) in the U.S. EEZ, including the state of Hawaii, the territories of American Samoa and Guam, the Commonwealth of the Northern Mariana Islands, and the U.S. Pacific Remote Island Areas and (2) on the high seas.

For purposes of EFH designation, managed pelagics are divided into four broad species assemblages, including temperate species, tropical species, sharks, and squid. The designation of these assemblages is based on similarity of ecological and habitat requirements of the included species. EFH for management units covered by the Pelagic Fisheries FEP is summarized in Table 3.8-8.

Table 3.8-8. Essential Fish Habitat Designated in the Pacific Pelagic Fishery Ecosystem Plan

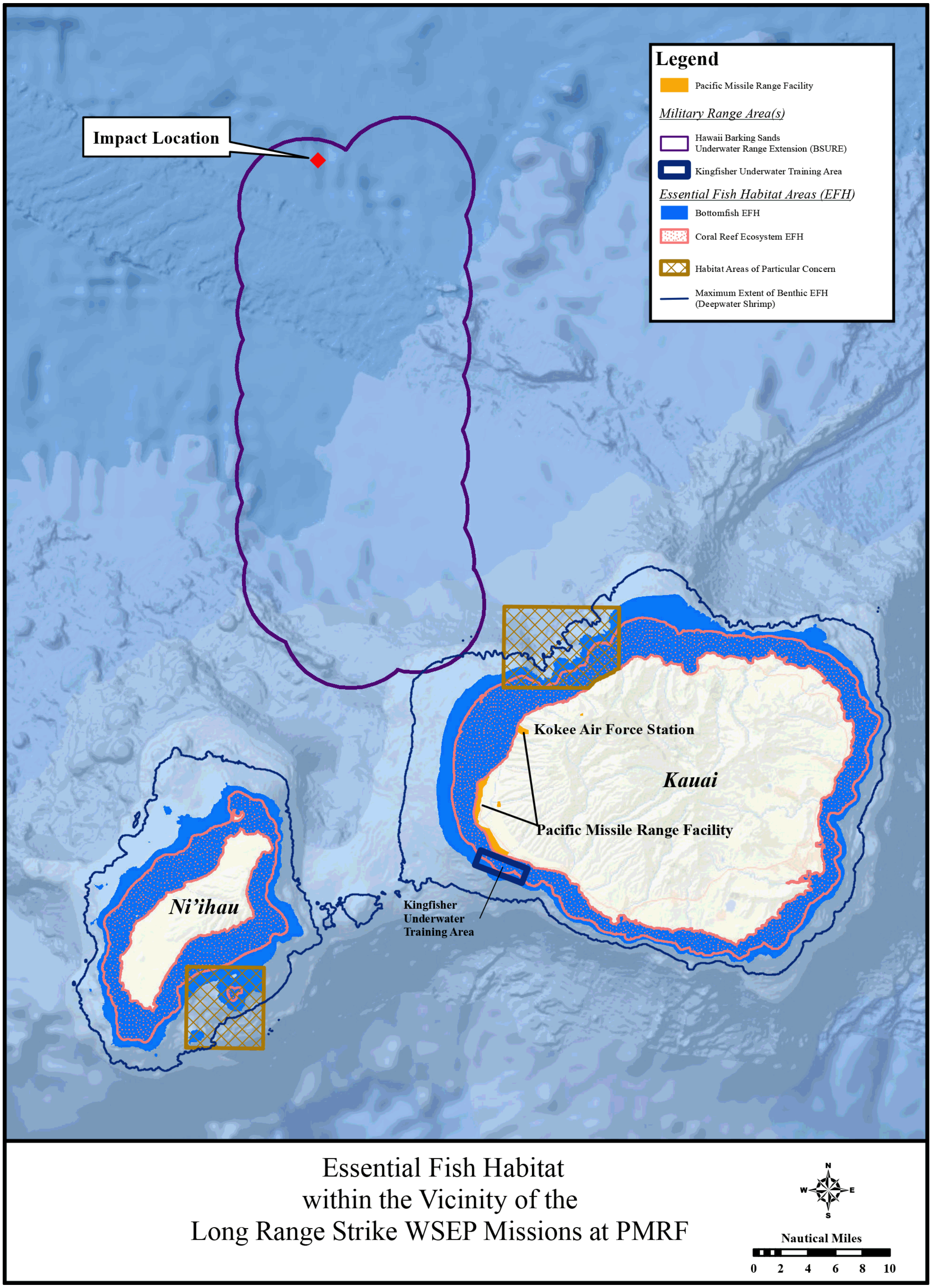
Species Complex	Designated Essential Fish Habitat	
	Adults and Juveniles	**Eggs and Larvae**
Temperate species Tropical species Sharks Squid	The water column down to a depth of 1,000 meters (500 fathoms), from the shoreline to the outer limit of the EEZ.	The epipelagic zone of the water column down to a depth of 200 meters (100 fathoms), from the shoreline to the outer limit of the EEZ.

EEZ = Exclusive Economic Zone

The WPRFMC has identified HAPCs as the water column down to 1,000 meters that occurs above all seamounts and banks within the EEZ shallower than 2,000 meters (1,000 fathoms). Although these deep bottom features do not necessarily constitute EFH themselves, they influence the overlying water column, particularly by facilitating ocean mixing and other processes that lead to greater biological productivity.

Figure 3.8-3 shows all EFH and HAPCs in the vicinity of the study area.

Figure 3.8-3. Essential Fish Habitat in the Study Area



3.8.3 Environmental Consequences

The potential impacts associated with Long Range Strike WSEP missions on each category of biological resources (marine mammals, sea turtles, fish, and EFH) are discussed in this section. Potential impact categories include physical strike by munitions, ingestion of military expended materials, water and sediment quality effects, and detonation effects (overpressure and acoustic components). Analysis is included for potential impact categories that are applicable to each biological resource.

3.8.3.1 No Action Alternative

Under the No Action Alternative, there would be no Long Range Strike WSEP missions and, therefore, no potential to impact biological resources in the BSURE area due to physical strike, ingestion of military expended materials, detonation effects, or water and sediment quality effects resulting from deposition of metals, explosives, explosion byproducts, or other chemical materials. There would be no change to existing conditions in the BSURE area or surrounding vicinity and no significant impacts to biological resources under the No Action Alternative.

3.8.3.2 Alternative 1 (Preferred Alternative)

3.8.3.2.1 Marine Mammals

Physical Strike

Marine mammals could be physically struck by weapons during Long Range Strike WSEP missions. A total of only nine weapons (one JASSM and eight SDBs) will be released during the first year of activities. Over the following five years, up to 550 bombs and missiles will be deployed, for an average of 110 per year. All weapons are scheduled to be deployed in summer. The velocity of bombs, missiles, and other munitions decreases quickly after striking the water and, therefore, injury and mortality are considered unlikely for animals swimming in the water column at depths of more than a few meters. Strike potential would generally be limited to animals located at the water surface or in the water column near the surface and would be affected by factors such as size and relative speed of the munition. Strike potential would be reduced by pre-mission surveys, avoidance of observed marine mammals in the mission area, and the generally dispersed distribution of marine mammals. Although the probability of a direct strike by weapons is not quantified, the Air Force considers it to be low.

Pursuant to the ESA, the Air Force has determined that the potential for physical strikes from Long Range Strike WSEP missions may affect, but are not likely to adversely affect, ESA-listed marine mammal species. Furthermore, population-level effects to marine mammal stocks and species would not occur. There would be no effect to Hawaiian monk seal critical habitat. Therefore, there would be no significant impacts to marine mammal species or stocks due to physical strikes from Long Range Strike WSEP activities.

Ingestion Stressors

Military expended materials that would be produced during Long Range Strike WSEP missions include inert munitions and fragments of exploded bombs and missiles. Intact, inert munitions would be too large to ingest. However, some munition fragments could be ingested by some species, possibly resulting in injury or death.

A small quantity of exploded weapon components, such as small plastic pieces, could float on the surface. Species feeding at the surface could incidentally ingest these floating items. Sei whales are known to skim feed, and there is potential for other species to feed at the surface. Laist (1997) provides a review of numerous marine mammal species that have been documented to ingest debris, including 21 odontocetes. Most of these species had apparently ingested debris floating at the surface. A marine mammal would suffer a negative impact from military expended materials if the item becomes imbedded in tissue or is too large to pass through the digestive system. Some of the items would be too large to ingest, and others would be small enough to pass through an animal's digestive system without harm. In addition, an animal would not likely ingest every expended item it encountered. The number of items at the surface encountered by a given animal would be decreased by the low initial density of items and dispersal by currents and wind. Due to the small amount of floating military expended materials produced and the dispersed nature of marine mammals and marine mammal groups potentially encountering an item at the surface, floating military expended materials are unlikely to negatively affect marine mammals.

Most military expended materials would not remain on the water surface but would sink at various rates of speed, depending on the density and shape of the item. Individual marine mammals feeding in the water column (for example, dolphins preying on fish or squid at middle depths) could potentially ingest a sinking item. Most items would sink relatively quickly and would not remain suspended in the water column indefinitely. In addition, not all items encountered would be ingested, as a marine mammal would probably be able to distinguish military expended materials from prey in many instances. Overall, sinking items are not expected to present a substantial ingestion threat to marine mammals.

Most of the military expended materials resulting from Long Range Strike WSEP missions would sink to the bottom and would probably eventually become encrusted and/or covered by sediments, although cycles of covering/exposure could occur due to water currents. Munition fragments would sink relatively quickly to the substrate. Several marine mammal species feed at or near the seafloor. For example, although sperm whales feed primarily on squid (presumably deep in the water column), demersal fish species are also sometimes consumed. Humpback whales may also feed near the bottom, and beaked whales use suction feeding to ingest benthic prey. Hawaiian monk seals feed on numerous species that may occur on or near the seafloor, including fish, cephalopods, and lobsters. Therefore, there is some potential for such species to incidentally ingest military expended materials while feeding. However, the potential for such encounters is low based on the relatively low number and patchy distribution of the items produced, the patchy distribution of marine mammal feeding habitat, and water depth at the impact location (over 4,000 meters). Further, an animal would not likely ingest every military expended material it encounters. Animals may attempt to ingest an item and then reject it after realizing it is not a food item. Additionally, ingestion of an item would not necessarily result in injury to mortality to the individual if the item does not become embedded in tissue (Wells et al., 2008). Therefore, impacts resulting from ingestion of military expended materials would be limited to the unlikely event where a marine mammal suffers a negative response from ingesting an item that becomes embedded in tissue or is too large to pass through the digestive system. Military expended materials that become encrusted or covered by sediments would have a lower potential for ingestion. In general, it is not expected that large numbers of items on the seafloor would be consumed and result in harm to marine mammals, particularly given the water depth at the impact location. Based on the discussion above, the Air Force considers potential impacts unlikely, and population-level effects on any species are considered remote.

In summary, there would be no significant impacts to marine mammal species or stocks due to ingestion of military expended materials. Pursuant to the ESA, the Air Force has determined that ingestion stressors resulting from Long Range Strike WSEP missions may affect, but are not likely to adversely affect, ESA-listed marine mammal species. There would be no effect to Hawaiian monk seal critical habitat. No long-term population-level effects to marine mammal stocks and species would occur.

Detonation Effects

Cetaceans spend their entire lives in the water and are submerged below the surface much of the time. When at the surface, unless engaging in behaviors such as jumping, spyhopping, etc., the body is almost entirely below the water's surface, with only the blowhole exposed to allow breathing. This can make cetaceans difficult to locate visually and also exposes them to underwater noise, both natural and anthropogenic, because their ears are nearly always below the water's surface. Hawaiian monk seals spend some portion of their time out of the water. However, when swimming under the surface (e.g., during foraging dives), seals are also exposed to natural and anthropogenic noise. As a result, marine mammals located near a detonation could be exposed to the resulting shock wave and acoustic energy. Potential effects include mortality, injury, impacts to hearing, and behavioral disturbance. As discussed in Section 1.6.1, the MMPA prohibits the take of marine mammals without an authorization from NMFS. *Take* is defined as harassing, hunting, capturing, or killing of any marine mammal. The term *harassment* is further categorized by level of severity as Level A or Level B. For military readiness activities such as Long Range Strike WSEP activities, harassment definitions are as follows:

- **Level A harassment** has the significant potential to injure a marine mammal or marine mammal stock in the wild.
- **Level B harassment** has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering, to a point where such behavioral patterns are abandoned or significantly altered.

The potential numbers and species of marine mammal exposures are assessed in this section. For a detailed description of the acoustic modeling methodology used to estimate pressure and acoustic exposures, as well as the model outputs, refer to the associated requests for an IHA and LOA, submitted to the NMFS pursuant to the MMPA (Appendix A).

Three sources of information are necessary for estimating potential acoustic effects on marine mammals: (1) the zone of influence, which is the distance from an explosion to which particular levels of impact would extend; (2) the density of animals within the zone of influence; and (3) the number of detonations (events). Each of these components is described in the following subsections.

Zone of Influence

The zone of influence is defined as the area or volume of ocean in which marine mammals could be exposed to various pressure or acoustic energy levels caused by exploding ordnance. The pressure and energy levels considered to be of concern are defined in terms of metrics, criteria, and thresholds. A *metric* is a technical standard of measurement that describes the acoustic environment (e.g., frequency duration, temporal pattern, and amplitude) and pressure at a given location. *Criteria* are the types of possible effects and include mortality, injury, and harassment. A *threshold* is the level of pressure or noise above which the impact criteria are reached. The analysis of potential impacts to marine mammals incorporates criteria and thresholds presented in Finneran and Jenkins (2012). The paragraphs below provide a general discussion of the various metrics, criteria, and thresholds used for impulsive noise impact assessment. More detailed information is provided in Appendix A.

Metrics

Standard impulsive and acoustic metrics were used for the analysis of underwater energy and pressure waves in this document. Several different metrics are important for understanding risk assessment analysis of impacts to marine mammals.

SPL (sound pressure level): A ratio of the absolute sound pressure and a reference level. Units are in decibels referenced to 1 micropascal (dB re 1 µPa).

SEL (sound exposure level): SEL is a measure of sound intensity and duration. When analyzing effects on marine animals from multiple moderate-level sounds, it is necessary to have a metric that quantifies cumulative exposures. SEL can be thought of as a composite metric that represents both the intensity of a sound and its duration. SEL is determined by calculating the decibel level of the cumulative sum of squared pressures over the duration of a sound, with units of decibels referenced to 1 micropascal-squared seconds (dB re 1 $\mu Pa^2 \cdot s$) for sounds in water.

Positive impulse: This is the time integral of the pressure over the initial positive phase of an arrival. This metric represents a time-averaged pressure disturbance from an explosive source. Units are typically pascal-seconds (Pa·s) or pounds per square inch per millisecond (psi·msec). There is no decibel analog for impulse.

Criteria and Thresholds

The criteria and thresholds used to estimate potential pressure and acoustic impacts to marine mammals resulting from detonations were obtained from the NMFS 2016 Technical Guidance (NMFS, 2016d) and Finneran and Jenkins (2012) and include mortality, injurious harassment (Level A), and noninjurious harassment (Level B). In some cases, separate thresholds have been developed for different species groups or functional hearing groups. Functional hearing groups included in the analysis are low-frequency cetaceans, mid-frequency cetaceans, high-frequency cetaceans, and phocids. Appendix A summarizes the thresholds and criteria discussed below that are used to estimate potential pressure and acoustic impacts to marine mammals resulting from detonations.

Mortality

Mortality risk assessment may be considered in terms of direct injury, which includes primary blast injury and barotrauma. The potential for direct injury of marine mammals has been inferred from terrestrial mammal experiments and from post-mortem examination of marine mammals believed to have been exposed to underwater explosions (Finneran and Jenkins, 2012; Ketten et al., 1993; Richmond et al., 1973; Yelverton et al., 1973). Actual effects on marine mammals may differ from terrestrial animals due to anatomical and physiological differences, such as a reinforced trachea and flexible thoracic cavity, which may decrease the risk of injury (Ridgway and Dailey, 1972).

Primary blast injuries result from the initial compression of a body exposed to a blast wave and are usually limited to gas-containing structures (e.g., lung and gut) and the auditory system (U.S. Navy, 2001). Barotrauma refers to injuries caused when large pressure changes occur across tissue interfaces, normally at the boundaries of air-filled tissues such as the lungs. Primary blast injury to the respiratory system may be fatal, depending upon the severity of the trauma. Rupture of the lung may introduce air into the vascular system, producing air emboli that can restrict oxygen delivery to the brain or heart.

Whereas a single mortality threshold was previously used in acoustic impacts analysis, species-specific thresholds are currently required. Thresholds are based on the level of impact that would cause extensive lung injury, resulting in mortality to 1 percent of exposed animals (that is, an impact level from which 1 percent of exposed animals would not recover) (Finneran and Jenkins, 2012). The threshold represents the expected onset of mortality, where 99 percent of exposed animals would be expected to survive. Most survivors would have moderate blast injuries. The lethal acoustic exposure level of a blast, associated with the positive impulse pressure of the blast, is expressed as Pa·s and is determined using the Goertner (1982) modified positive impulse equation. This equation incorporates source/animal depths and the mass of a newborn calf for the affected species. The threshold is conservative because animals of greater mass can withstand greater pressure waves, and newborn calves typically make up a very small percentage of any marine mammal group. While the mass of newborn calves for some species are provided in literature, in many cases this information is unknown, and a surrogate species (considered to be generally comparable in mass) is used instead. Finneran and Jenkins (2012) provide known or surrogate masses for newborn calves of several cetacean species. The Goertner equation, as presented in

Finneran and Jenkins (2012), is used in the acoustic model to develop impacts analysis in this EA/OEA. The equation is provided in Appendix A, which describes the acoustic modeling methodology.

Injury (Level A Harassment)

Three categories of blast-related injury (Level A harassment) are currently recognized by NMFS: gastrointestinal (GI) tract injury, slight lung injury, and irrecoverable auditory damage (permanent threshold shift [PTS]).

Gastrointestinal tract injuries. Though often secondary in life-threatening severity to pulmonary blast trauma, the GI tract can also suffer contusions and lacerations from blast exposure, particularly in air-containing regions of the tract. Although hemorrhage of solid organs (e.g., liver, spleen, and kidney) from blast exposure is possible, rupture of these organs is rarely encountered. GI tract injuries are correlated with the peak pressure of an underwater detonation. GI tract injury thresholds are based on the results of experiments in the 1970s in which terrestrial mammals were exposed to small charges. The peak pressure of the shock wave was found to be the cause of recoverable contusions (bruises) in the GI tract (Richmond et al., 1973, cited in Finneran and Jenkins, 2012). The experiments found that a peak SPL of 237 dB re 1 μPa predicts the onset of GI tract injuries, regardless of an animal's mass or size. Therefore, the unweighted peak SPL of 237 dB re 1 μPa is used in explosive impacts assessments as the threshold for slight GI tract injury for all marine mammals.

Slight lung injury. This threshold is based on a level of exposure where most animals may experience slight blast injury to the lungs, but all would survive (zero percent mortality) (Finneran and Jenkins, 2012). Similar to the mortality determination, the metric is positive impulse and the equation for determination is that of the Goertner injury model (1982), corrected for atmospheric and hydrostatic pressures and based on the cube root scaling of body mass (Richmond et al., 1973; DoN, 2001). The equation is provided in Appendix A.

Auditory damage (permanent threshold shift). Another type of injury correlated to Level A harassment is PTS, which is auditory damage that does not fully recover and results in a permanent decrease in hearing sensitivity. There have been no studies to directly determine the onset of PTS in marine mammals and, therefore, this threshold is estimated from available information associated with temporary threshold shift (TTS). NMFS's Technical Guidance (NMFS, 2016d) defines separate PTS thresholds for three groups of cetaceans based on hearing sensitivity (low frequency, mid-frequency, and high frequency) and for phocids. Dual criteria are provided for PTS thresholds, one based on the SEL and one based on the SPL of an underwater blast. For a given analysis, the more conservative of the two is typically applied. The PTS thresholds are provided in Appendix A.

Noninjurious impacts (Level B harassment)

Two categories of noninjurious Level B harassment are currently recognized: TTS and behavioral impacts. Although TTS is a physiological impact, it is not considered injury, because auditory structures are temporarily fatigued instead of being permanently damaged.

Temporary threshold shift. Noninjurious effects on marine mammals, such as TTS, are generally extrapolated from data on terrestrial mammals (Southall et al., 2007). Similar to PTS, dual criteria are provided for TTS thresholds, and the more conservative is typically applied in impacts analysis. TTS criteria are based on data from impulse sound exposures when available. If impulse TTS data are not available, data from nonimpulse exposures may be used. For species where no data exist, TTS thresholds are based on the most closely related species for which data are available. The TTS thresholds are obtained from the NMFS 2016 Technical Guidance (NMFS, 2016d) and provided in Appendix A.

Behavioral impacts. Behavioral impacts refer to disturbances that may occur at acoustic levels below those considered to cause TTS in marine mammals, particularly in cases of multiple detonations. During an activity with a series of explosions (not concurrent multiple explosions), an animal is expected to exhibit a startle reaction to the first detonation followed by a behavioral response after multiple detonations. At close ranges and high sound levels, avoidance of the area around the explosions is the assumed behavioral response in most cases. Behavioral impacts may include decreased ability to feed, communicate, migrate, or reproduce, among others. Such effects, known as sub-TTS Level B harassment, are based on observations of behavioral reactions in captive dolphins and beluga whales exposed to pure tones, a different type of sound than that produced from a detonation (Finneran and Schlundt, 2004; Schlundt et al., 2000). Behavioral effects are generally considered to occur when animals are exposed to multiple, successive detonations at the same location within a 24-hour period. Behavioral thresholds are set 5 dB below the SEL-based TTS threshold unless there are specific data for species or groups indicating a lower threshold should be used. For single detonations, behavioral disturbance is likely limited to short-term startle reactions. The behavioral impact thresholds for marine mammals exposed to multiple, successive detonations are provided in Appendix A.

Marine Mammal Density

For purposes of impacts analysis, the number of marine mammals potentially affected may be considered in terms of density, which is the number of animals present in the area affected by a given detonation. A significant amount of effort is required to collect and analyze survey data sufficient for producing useable marine species density estimates. As a result, there is often no single source of density available for every area, species, and season; density data are often compiled from multiple sources. The density estimates used for acoustic analysis in this document are from the U.S. Navy's Marine Species Density Database for the Pacific region, which includes the HRC (DoN, 2014). The Navy database includes a compilation of the best available density data from several primary sources and published works, including survey data from NMFS within the Hawaiian Islands EEZ. NMFS publishes annual SARs for various regions of U.S. waters, which cover all stocks of marine mammals within those waters (for abundance and distribution information of species potentially occurring within the study area, see Muto et al. [2016], Carretta et al. [2016], and Bradford et al. [2015]). Other researchers often publish density data or research covering a particular marine mammal species, which is integrated into the SARs. The Navy's Marine Species Density Database is considered the most comprehensive and relevant information source available for the study area and has been endorsed by NMFS for use in impacts analysis of numerous past military actions conducted at and near the study area. Marine mammal density estimates used for acoustic analysis are provided in the associated requests for IHA and LOA (Appendix A).

Density is typically reported for an area (e.g., animals per square kilometer). Density estimates usually assume that animals are uniformly distributed within the affected area, even though this is rarely true. Marine mammals may be clumped in areas of greater importance; for example, animals may be more concentrated in areas offering high productivity, lower predation, safe calving, etc. However, because there are usually insufficient data to calculate density for small areas, an even distribution is typically assumed for impact analyses.

Although the study area is depicted as only the surface of the water, in reality, density implicitly includes animals anywhere within the water column under that surface area. Assuming that marine mammals are distributed evenly within the water column does not accurately reflect animal behaviors. Applying a depth distribution, based on the results of tagging studies and other investigations, would allow impacts to be based on a three-dimensional distribution of marine mammals. Based on current regulatory guidance from NMFS for 2016 missions, density is assumed to be two-dimensional, and exposure estimates are calculated as the product of affected area, animal density, and number of events. However, for 2017–2021 missions, a depth distribution adjustment, provided in Watwood and Buonantony (2012), is applied to marine mammal densities. By combining marine mammal density with depth information, three-dimensional density estimates are possible. These estimates allow for more accurate modeling of potential exposures from specific acoustic sources.

Number of Events

An "event" refers to a single, unique action that has the potential to expose marine mammals to pressure and/or acoustic levels associated with take under the MMPA. For Long Range Strike WSEP activities, the number of events generally corresponds to the number of live ordnance items released within a 24-hour period. For 2016 missions, all live ordnance being released are proposed to occur on the same mission day, which would equate to a single event with multiple releases. Up to four SDBs may be released simultaneously and would detonate within a few seconds of each other in the same vicinity and is referred to as a "burst." Under such a detonation scenario, the energy from all four munitions in the burst is summed, but the pressure component is not. For 2016 missions, one JASSM/JASSM-ER release and two SDB-I bursts (eight total SDB-I munitions) releases are proposed. The JASSM/JASSM/ER release would occur separately from each SDB-I burst release, but the total energy for all releases in a 24-hour period is summed for impact calculations. For 2017–2021, the exact number and type of munitions that would be released each day is not known and would vary. To account for total annual impacts, the total number of each munition proposed to be released per year was divided by five (annual number of mission days), which was treated as a representative mission day. Consistent with the 2016 mission approach, the total energy for all weapon releases as part of a representative mission day is summed for impact calculations. Unlike 2016, there will be a total of five mission days per year during the time frame of 2017–2021. Refer to Appendix A for a detailed explanation of modeling methods.

Exposure Estimates

The maximum estimated range, or radius, from the detonation point to which the various thresholds extend for all munitions proposed to be released in a 24-hour time period was calculated based on explosive acoustic characteristics, sound propagation, and sound transmission loss in the Study Area, which incorporates water depth, sediment type, wind speed, bathymetry, and temperature/salinity profiles. Ranges were calculated separately for the 2016 and 2017–2021 missions, based on munitions expected to be released during a typical mission day and the different approaches requested by NMFS during the consultation process.

The impact ranges calculated for 2016 missions were used to determine the total area (circle) of the zones of influence for each criterion/threshold. To eliminate "double-counting" of animals, impact areas from higher impact categories (e.g., mortality) were subtracted from areas associated with lower impact categories (e.g., Level A harassment). The estimated number of marine mammals potentially exposed to the various impact thresholds was then calculated as the product of the adjusted impact area, animal density, and number of events per year. Impacts for 2017–2021 missions were calculated as three-dimensional impact volumes to determine zones of influence. The estimated number of marine mammals potentially exposed to the various impact thresholds was then calculated as the product of the impact volume, scaled animal density (based on the depth distribution for each species as provided in Watwood and Buonantony [2012]), and number of events per year. To eliminate "double-counting" of animals, exposure estimates from higher impact categories (e.g., mortality) were subtracted from exposure estimates from lower impact categories (e.g., Level A harassment).

Since the acoustic model accumulates energy from all detonations with a 24-hour time frame, it is assumed that the same population of animals is being impacted within that time period. The population would refresh after 24 hours. Details of the acoustic modeling method are provided in the associated Biological Assessment and requests for an IHA and LOA (Appendix A). For metrics with multiple criteria (e.g., slight lung injury, GI tract injury, and PTS for Level A harassment) and criteria with two thresholds (e.g., 187 dB SEL and 230 peak SPL for PTS), the criterion and/or threshold that results in the highest exposure estimate was used for impact calculations.

Missions Conducted in 2016

Immediate evaluations for JASSM/JASSM-ER and SDB I/II are needed for a smaller number of munitions in 2016, compared with the level of activities proposed for 2017–2021. Therefore, the potential impacts resulting from 2016 missions are discussed separately. Weapon release parameters for the 2016 mission would involve the release of one live JASSM and eight live SDB-I. As described previously, up to four SDB-I/II munitions would be released simultaneously; however the SDB-I releases would occur separately from the JASSM. The resulting total number of marine mammals potentially exposed to the various levels of thresholds is listed in Table 3.8-9. An animal is considered “exposed’ to a sound if the received sound level at the animal’s location is above the background ambient noise level within a similar frequency band. The exposure calculations from the model output resulted in decimal values, suggesting in most cases that a fraction of an animal was exposed. To eliminate this, the acoustic model results were rounded to the nearest whole animal to obtain the exposure estimates.

Table 3.8-9. Number of Marine Mammals Affected by the 2016 Long Range Strike WSEP Mission Proposed for 2016, Under Alternative 1 (Preferred Alternative)

Species	Mortality	Level A Harassment (PTS)	Level B Harassment (TTS)	Level B Harassment (Behavioral)
Mysticetes (baleen whales)				
Humpback whale	0	0	3	9
Blue whale	0	0	0	0
Fin whale	0	0	0	0
Sei whale	0	0	0	0
Bryde’s whale	0	0	0	0
Minke whale	0	0	1	2
Odontocetes (toothed whales and dolphins)				
Sperm whale	0	0	0	0
Pygmy sperm whale	0	0	3	26
Dwarf sperm whale	0	1	9	64
Killer whale	0	0	0	0
False killer whale	0	0	0	0
Pygmy killer whale	0	0	0	0
Short-finned pilot whale	0	0	0	0
Melon-headed whale	0	0	0	0
Bottlenose dolphin	0	0	0	0
Pantropical spotted dolphin	0	0	0	0
Striped dolphin	0	0	0	0
Spinner dolphin	0	0	0	0
Rough-toothed dolphin	0	0	0	0
Fraser’s dolphin	0	0	1	0
Risso’s dolphin	0	0	0	0
Cuvier’s beaked whale	0	0	0	0
Blainville’s beaked whale	0	0	0	0
Longman’s beaked whale	0	0	0	0
Pinnipeds				
Hawaiian monk seal	0	0	0	0
Total	**0**	**1**	**17**	**101**

PTS = permanent threshold shift; TTS = temporary threshold shift

Marine mammal species for which exposure to any threshold is estimated include humpback whale, minke whale, pygmy sperm whale, dwarf sperm whale, and Fraser's dolphin. Individuals from these species are associated with Hawaii stocks, and none are listed under the ESA or considered depleted under the MMPA. The Hawaii DPS of humpback whales was recently delisted under the ESA, based on NMFS's final rule issued on September 8, 2016 (81 FR 62260, September 8, 2016), and effective on October 11, 2016. Based on acoustic modeling results, no marine mammals would be exposed to pressure or energy levels associated with mortality, slight lung injury, or GI tract injury. Approximately 1 dwarf sperm whale could be exposed to energy levels associated with PTS. Additionally, 9 dwarf sperm whales 3 pygmy sperm whales, 3 humpback whales, 1 minke whale, and 1 Fraser's dolphin could experience TTS, and about 64 dwarf sperm whales, 26 pygmy sperm whales, 9 humpback whales, and 2 minke whales could experience behavioral effects. None of the estimated exposure numbers take into account the mitigation measures outlined in Chapter 5, which are expected to reduce the number and severity of effects.

Missions Conducted from 2017 to 2021

As shown in Table 2.2-1, Long Range Strike WSEP missions proposed for 2017–2021 under Alternative 1 would consist of up to 6 live JASSM, 30 SDB-I, 30 SDB-II, 10 HARM, and 30 JDAM munitions per year. Under Alternative 1, all JDAM releases would consist of a 10 millisecond time-delayed fuse resulting in a subsurface detonation at approximately 10-foot water depth. All other weapons would detonate upon impact with the water surface. The resulting total number of marine mammals potentially exposed to the various levels of thresholds under Alternative 1 is shown in Table 3.8-10. When assessing impacts from 2017–2021 missions, exposure calculations resulted in decimal values, suggesting in most cases that a fraction of an animal was exposed. To eliminate this, the model results were rounded to the nearest whole animal. In addition, to eliminate "double-counting" of animals, exposure results from higher impact categories (e.g., mortality) were subtracted from lower impact categories (e.g., Level A harassment). The numbers shown in Table 3.8-10 represent total impacts for all detonations combined per year.

Table 3.8-10. Annual Number of Marine Mammals Potentially Affected by Long Range Strike WSEP Missions Proposed for 2017-2021 Under Alternative 1 (Preferred Alternative)

Species	Mortality	Level A Harassment (PTS)	Level B Harassment (TTS)	Level B Harassment (Behavioral)
Mysticetes (baleen whales)				
Humpback whale	0	0	0	0
Blue whale	0	0	0	0
Fin whale	0	0	0	0
Sei whale	0	0	0	0
Bryde's whale	0	0	0	0
Minke whale	0	0	0	0
Odontocetes (toothed whales and dolphins)				
Sperm whale	0	0	0	1
Pygmy sperm whale	0	4	21	55
Dwarf sperm whale	0	10	51	136
Killer whale	0	0	0	0
False killer whale (MHI Insular stock)	0	0	0	1
False killer whale (all other stocks)	0	0	0	0
Pygmy killer whale	0	0	1	2

Table 3.8-10. Annual Number of Marine Mammals Potentially Affected by Long Range Strike WSEP Missions Proposed for 2017-2021 Under Alternative 1 (Preferred Alternative) (Cont'd)

Species	Mortality	Level A Harassment (PTS)	Level B Harassment (TTS)	Level B Harassment (Behavioral)
Short-finned pilot whale	0	0	3	5
Melon-headed whale	0	0	0	1
Bottlenose dolphin	0	0	1	2
Pantropical spotted dolphin	0	0	2	3
Striped dolphin	0	0	1	2
Spinner dolphin	0	0	1	1
Rough-toothed dolphin	0	0	2	3
Fraser's dolphin	0	0	7	11
Risso's dolphin	0	0	1	2
Cuvier's beaked whale	0	0	0	0
Blainville's beaked whale	0	0	0	1
Longman's beaked whale	0	0	1	1
Pinnipeds				
Hawaiian monk seal	0	0	0	0
Total	**0**	**14**	**92**	**227**

MHI = Main Hawaiian Islands; PTS = permanent threshold shift; TTS = temporary threshold shift

Based on acoustic modeling, and in the absence of mitigation measures, there would be no marine mammals affected by impulse pressure levels associated with mortality. A total of 14 marine mammals (10 pygmy sperm whales and 4 dwarf sperm whales) could potentially be exposed annually to injurious Level A harassment resulting from auditory injury. Auditory injury is a reduction in hearing ability resulting from overstimulation to sounds. The mechanisms differ from those of auditory trauma and include damage or distortion of the tympanic membrane and hair cells, hair cell death, changes in cochlear blood flow, and cochlear nerve swelling. Auditory injury is manifested as hearing loss, also called noise-induced threshold shift. Level A harassment is associated with permanent effects (PTS), where some portion of the threshold shift remains indefinitely. Animals are most susceptible to auditory injury within their most sensitive hearing range. The greater the degree of threshold shift, the smaller the ocean space within which an animal can detect biologically relevant sounds. For example, deafness would affect social communications, navigation, foraging, and predator detection. The threshold resulting in the highest exposure estimates was used to determine takes. Impacts are associated with the applicable SEL threshold, which corresponds to the onset of PTS. If an animal suffers trauma or auditory injury, a physiological stress response will typically occur. A stress response generally involves the release of hormones and other biochemicals into the bloodstream to help the animal in responding to the stressor.

A total of approximately 92 marine mammals could potentially be exposed to sound corresponding to noninjurious (TTS) Level B harassment, annually from 2017–2021 missions. The majority of odontocete species that occur in the study area have some calculated level of estimated TTS exposure, none of which are ESA-listed species. Most exposures are associated with pygmy and dwarf sperm whales (combined total of 72 exposures). TTS impacts are not expected for any mysticete species. Similar to the preceding discussion of auditory injury, auditory fatigue is a reduction in hearing ability resulting from overstimulation to sounds that may result from damage or distortion of the tympanic membrane and hair cells, hair cell death, changes in cochlear blood flow, and cochlear nerve swelling. The distinction between PTS and TTS is based on whether there is complete recovery of hearing sensitivity following a sound exposure. If the animal's hearing ability eventually returns to pre-exposure levels, the threshold shift is considered temporary. Studies of terrestrial mammals show that large amounts of TTS (approximately 40 dB measured 24 hours after exposure) can result in permanent neural degeneration, despite the hearing thresholds returning to normal. As with PTS, animals are most susceptible to auditory fatigue within their most sensitive hearing range. The greater the degree of threshold shift, the smaller the ocean space within which an animal can detect biologically relevant sounds. The threshold resulting in the highest exposure estimates was used to determine takes. Similar to the discussion of PTS, the SEL metrics resulted in higher exposure estimates compared with peak SPL metrics and were conservatively used for impacts analysis

Approximately 227 additional marine mammals could potentially be exposed to acoustic levels corresponding to applicable Level B behavioral thresholds during Long Range Strike WSEP 2017–2021 missions annually. Most odontocete species that occur in the study area have some calculated level of estimated behavioral impact, including two ESA-listed species: sperm whale (one estimated exposure) and false killer whale (Main Hawaiian Insular stock) (one estimated exposure). However, similar to the results for TTS, most odontocete exposures are associated with the pygmy and dwarf sperm whales (combined total of 191 exposures). Behavioral impacts are not expected for any mysticete species. Behavioral harassment occurs at distances beyond the range of structural damage and hearing threshold shift. Numerous behavioral responses can result from physiological responses. An animal may react to a stimulus based on a number of factors in addition to the severity of the physiological response. An animal's previous experience with the same or a similar sound, the context of the exposure, and the presence of other stimuli contribute to determining its reaction. Behavioral responses fall into two major categories: alterations in natural behavior patterns and avoidance. These types of reactions are not mutually exclusive, and overall reactions may be combinations of behaviors or a sequence of behaviors. Severity of behavioral reactions can vary substantially, from minor and brief reorientations of the animal to investigate the sound to severe reactions such as aggression or prolonged flight. The type and severity of the behavioral response will determine the energetic cost to the animal. Possible behavioral responses to a detonation include panic, startle, departure from an area, and disruption of activities such as feeding or breeding, among others.

The magnitude and type of effect, as well as the speed and completeness of recovery, affect the long-term consequences to individual animals and populations. Animals that recover quickly and completely from explosive effects will not likely suffer reductions in their health or reproductive success or experience changes in their habitat utilization. In such cases, no population-level effects would be expected. Animals that do not recover quickly and fully could suffer reductions in their health and reproductive success, they could be permanently displaced or change how they utilize the environment, or they could die. Frequent disruptions to natural behavior patterns may not allow an animal to fully recover between exposures, which would increase the probability of long-term consequences to individuals. Long-term consequences to individuals can lead to population-level consequences.

As described in the associated requests for an IHA and LOA (Appendix A), consideration of "negligible impact" is required by NMFS to authorize incidental take of marine mammals. An activity has a negligible impact on a species or stock when it is determined that the total taking is not likely to reduce annual rates of adult survival or recruitment (offspring survival, birth rates). Potential impacts associated with the proposed actions consist of Level A harassment (PTS) and Level B harassment (TTS and behavioral effects). Behavioral reactions of marine mammals to sound are known to occur but are difficult to predict. Behavioral studies indicate that reactions, if any, are highly contextual and vary between species and individuals within a species (Moretti et al., 2010; Southall et al., 2011; Thompson et al., 2010; Tyack, 2009b; Tyack et al., 2011). Depending on the context, marine mammals often change their activity when exposed to disruptive levels of sound. For example, when sound becomes disruptive, cetaceans at rest may become active, and feeding or socializing cetaceans or pinnipeds often interrupt these events by diving or swimming away. Studies on the effects of active sonar (a nonimpulsive sound) on marine mammals have been undertaken within the PMRF. Martin et al. (2015) found that the number of minke whale calls detected on the range's hydrophones decreased with the use of active sonar (time frame of 2011 to 2013). Blaineville's beaked whales underwent fewer dives during sonar use compared to periods without sonar use, and there is some indication that individuals moved toward the edges of the range (Martin et al., 2016). Conversely, Baird et al. (2014) investigated movements of satellite-tagged bottlenose dolphins, short-finned pilot whales, and rough-toothed dolphins exposed to active sonar and found no indication of large-scale movement away from the sound, although the authors note some limitations in the study. If the sound disturbance occurs around a haul-out site, pinnipeds may move back and forth between water and land or eventually abandon the site. When attempting to understand behavioral disruption by anthropogenic sound, a key consideration is whether the exposures have biologically significant consequences for the individual or population (National Research Council of the National Academies, 2005).

If a marine mammal does react to an underwater sound by changing its behavior or moving a small distance, the impacts of the change may not be important to the individual. For example, during a study of dolphin response to whale watching vessels in New Zealand, researchers found that when animals can cope with constraint and easily feed or move elsewhere, there is little effect on survival (Lusseau and Bejder, 2007). On the other hand, if a sound source displaces marine mammals from an important feeding or breeding area for a prolonged period and they do not have an alternate, equally desirable area, impacts on the animals could be negative, because the disruption has biological consequences. Biological parameters or key elements having greatest importance to a marine mammal relate to its ability to mature, reproduce, and survive.

The importance of the disruption and degree of consequence for individual marine mammals is often dependent on the frequency, intensity, and duration of the disturbance. Isolated acoustic disturbances such as underwater detonations are expected to have minimal consequences and no lasting effects on marine mammal populations. Marine mammals regularly cope with occasional disruption of their activities by predators, adverse weather, and other natural phenomena. It is reasonable to assume that they can tolerate occasional or brief disturbances by anthropogenic sound without significant consequences. However, prolonged disturbance, as might occur if a stationary and noisy activity were established near a concentrated area, is a more important concern. The long-term implications would depend on the degree of habituation within the population. If the marine mammals fail to habituate or become sensitized to disturbance and, as a consequence, are excluded from an important area or are subject to stress while at the important area, long-term effects could occur to individuals or the population.

The following points provide a context for evaluating the potential to impact individual marine mammals or marine mammal populations:

- Estimated mortality impacts essentially zero.
- Nearly all acoustic harassment effects are within the noninjurious TTS or behavioral effects zones (Level B harassment); the estimated number of animals potentially affected by Level A harassment (injury) is relatively small (30 exposures).
- The take numbers summarized in the preceding paragraphs are conservative (overestimates) because they do not take into account required mitigation measures resulting from consultations with NMFS and described in Chapter 5. These measures are expected to substantially decrease the potential for explosive and acoustic impacts, especially within the injury zone. In addition, exposure calculations are based on the assumption that all animals would occupy the same depth within the water column and do not take into account diving behavior which could decrease exposure levels.

Conclusion

Pursuant to the ESA, the Air Force has determined that detonation effects from Long Range Strike WSEP missions proposed for 2016 may affect but are not likely to adversely affect blue whales, fin whales, sei whales, sperm whales, false killer whales (Main Hawaiian Insular Stock), and Hawaiian monk seals. With the issuance of the final rule to delist the Hawaii DPS of humpback whales, this species was no longer considered as part of the Section 7 consultation. The Air Force has also determined that detonation effects from Long Range Strike WSEP missions proposed for 2017-2021 may affect, and are likely to adversely affect, sperm whales and false killer whales. Although impacts to individuals of some species are likely (Level B harassment), potential impacts are not expected to result in long-term population level effects. There would be no effect to Hawaiian monk seal critical habitat. The Air Force entered into consultation under Section 7 of the ESA with NMFS and received a BO and Incidental Take Statement for 2016 missions on September 29, 2016. NMFS concurred with the Air Force determinations that ESA-listed marine mammals are not likely to be adversely affected by the proposed action (Consultation Number FPR-2016-9160). A Programmatic BO and Incidental Take Statement will be issued for 2017–2021 Long Range Strike WSEP activities before missions are conducted in 2017.

Pursuant to the MMPA, Long Range Strike WSEP missions proposed for 2016 would not cause mortality but would result in Level A harassment and Level B harassment to small numbers of five marine mammal species (humpback whale, minke whale, dwarf sperm whale, pygmy sperm whale, and Fraser's dolphin). Therefore, based on the acoustic modeling results, the Air Force requested authorization under the MMPA in the form of an IHA for 2016 missions. NMFS issued the IHA on September 27, 2016, and it is valid from October 1, 2016, through November 30, 2016. Long Range Strike WSEP missions proposed for 2017–2021 also have the potential to expose individual marine mammals to Level A harassment and Level B harassment. The Air Force is, therefore, requesting authorization under the MMPA in the form of an LOA for missions proposed for 2017–2021 under the Preferred Alternative. Missions will not be conducted in 2017 until NMFS issues the LOA to the Air Force. Based on the information provided above, including a description of marine mammal species with potential occurrence in the study area, the potential number and types of take, and adherence to mitigation measures described in Chapter 5, the Air Force concludes there would likely be no population-level effects to any marine mammal species or stock. Therefore, there would be no significant impacts to marine mammals resulting from Long Range Strike WSEP missions.

3.8.3.2.2 Sea Turtles

Physical Strike

Similar to the discussion of marine mammals, sea turtles could be struck by weapons during Long Range Strike WSEP missions. While impact from an item as it falls through the water column is possible, it is not likely, because objects generally sink through the water slowly and can be avoided by most sea turtles. Therefore, strikes are only considered reasonably likely for turtles located at or within a few meters of the surface. In order to be struck, a turtle would have to be in the impact area at the point of impact, near the surface at the same time the weapon arrives. Only nine weapons (one JASSM and eight SDBs) will be released during 2016 missions. Over the following five years, up to 550 bombs and missiles will be deployed, for an average of 110 per year. Due to the number of weapons used and the generally scattered turtle distribution, it is unlikely that a sea turtle would be at the water surface at the same time and location where weapons would impact the water. In addition, turtles are submerged approximately 90 percent of the time, so time spent at the surface is limited. Required mitigation measures would further decrease the probability of a weapon strike.

Pursuant to the ESA, the Air Force has determined that the potential for physical strike from Long Range Strike WSEP mission may affect, but are not likely to adversely affect ESA-listed sea turtle species. Population-level effects are not anticipated for any ESA-listed sea turtle species. Therefore, there would be no significant impacts to sea turtles due to physical strikes from Long Range Strike WSEP activities.

Ingestion Stressors

As described in the preceding marine mammal section, military expended materials potentially generated during Long Range Strike WSEP missions would include inert munitions and fragments of exploded bombs and missiles. Intact munitions would be too large to ingest, while some munition fragments could potentially be ingested. Sea turtle ingestion of plastics and other discarded items is well documented and may cause injury or death. The variety of debris items found in turtles suggests that feeding is at least somewhat nondiscriminatory and that they are prone to ingesting nonprey items. The impacts of ingested debris may be direct or indirect. For example, items may become lodged in the digestive tract and affect turtles by decreasing the ability to feed and absorb nutrients.

The potential for ingestion of military expended materials is a function of the quantity of items generated, location of the items, and sea turtle feeding methods. Floating materials or materials suspended in the water column could be eaten by turtles that feed at or near the surface, such as the leatherback, while items such as munition fragments on the seafloor could be ingested by other species. A small number of floating items small enough to be ingested by a turtle, such as small munition fragments, could remain on the water surface for some time. If ingested, effects to an individual turtle would depend on the size and shape of the item relative to the size of the animal. Items could either pass through the digestive tract without incident, cause temporary disruption of feeding and digestion processes, or become permanently encapsulated by the stomach lining. The probability of a turtle encountering and eating floating military expended materials would be decreased by the small number of items produced during missions, dispersion by ocean currents and wind, and the patchy distribution of turtles in the Pacific Ocean.

Most military expended materials would sink to the seafloor, and small items could be ingested by bottom-feeding turtles, including the loggerhead, olive ridley, hawksbill, and green turtle. Potential effects to an animal's health would be the same as those described for floating items above. The likelihood of ingestion is decreased by the water depth at which items would be deposited (bottom-feeding species are not known to routinely feed in water depths of over 4,000 meters). In addition, the potential for such encounters is low based on the relatively low number and patchy distribution of the items produced and the patchy distribution of sea turtle feeding habitat. Further, an animal would not likely ingest every military expended material it encounters. Animals may attempt to ingest an item and then reject it after realizing it is not a food item. Ingestion of an item would not necessarily result in injury or mortality to the individual if the item does not become embedded in tissue. Therefore, impacts resulting from ingestion of military expended materials would be limited to the unlikely event that a sea turtle suffers a negative response from ingesting an item that becomes embedded in tissue or is too large to pass through the digestive system. Over time, many military expended materials would eventually become covered by sediment or colonized by attaching and encrusting organisms, which could reduce the potential for ingestion. Overall, it is not expected that large numbers of expended items on the seafloor would be consumed and result in harm to sea turtles.

Pursuant to the ESA, the Air Force considers that ingestion stressors resulting from Long Range Strike WSEP missions may affect, but are not likely to adversely affect, ESA-listed sea turtle species. Population-level effects on any ESA-listed sea turtle species are considered unlikely. Therefore, there would be no significant impacts to sea turtles resulting from ingestion of military expended materials from Long Range Strike WSEP missions.

Detonation Effects

Sea turtles spend most of their lives at sea, coming ashore only to nest and, in rare circumstances and locations, to bask. When at the water surface, sea turtles are mostly submerged. This makes turtles difficult to locate visually and also exposes them to effects of underwater explosions. Similar to other marine species, the susceptibility of sea turtles to mortality, injury, or harassment resulting from underwater detonations is influenced by factors such as animal size, animal and detonation depth, and distance between the animal and detonation. Near the detonation point, animals may be affected primarily by the shock wave, with typical effects including compression of gas-containing structures (e.g., lungs, GI tract), large pressure changes across tissue interfaces, and concussive effects (e.g., bone fractures). Pressure may also result in effects to the auditory system such as ear drum rupture.

The greatest potential for direct, nonauditory tissue impacts to sea turtles is primary blast injury and barotrauma after exposure to the shock waves of high-amplitude impulsive sources, such as explosions. Primary blast injuries result from the initial compression of a body exposed to the high pressure of a blast or shock wave. As described in DoN (2015b), primary blast injury is usually limited to gas-containing structures (e.g., lung and gut) and the pressure-sensitive components of the auditory system, although additional injuries could include concussive brain damage and cranial, skeletal, or shell fractures. Barotrauma refers to injuries caused when large pressure changes occur across tissue interfaces, normally at the boundaries of air-filled tissues such as the lungs. Primary blast injury to the respiratory system may be fatal, depending on the severity of the trauma. Rupture of the lung may introduce air into the vascular system, producing air blockages that can restrict oxygen delivery to the brain and heart. Although often secondary in life-threatening severity to pulmonary blast trauma, the gastrointestinal tract can also suffer bruising and tearing from blast exposure, particularly in air-containing regions of the tract. Potential traumas include internal bleeding, bowel perforation, tissue tears, and ruptures of the hollow abdominal organs. Although hemorrhage of solid organs (e.g., liver, spleen, and kidney) from blast exposure is possible, rupture of these organs is rarely encountered. Nonlethal injuries could increase a sea turtle's risk of predation, disease, or infection.

Sound produced by an underwater explosion may cause other hearing effects, including hearing threshold shifts. A threshold shift occurs when intense sound causes fatigue or damage to the auditory system, resulting in a shift in the sound level that can be heard at a given frequency. That is, at the affected frequency, sound must be louder to be heard compared with the hearing ability before the shift. Such a shift may be temporary (TTS) or permanent (PTS). At greater distances from the detonation, noise may cause stress or disruption of natural behaviors. Startle reactions may include increased surfacing, rapid swimming, or diving. Noise due to mission activities may affect habitat quality such that important biological behaviors may be disrupted (e.g., feeding, mating, and resting), and turtles may avoid the area because of the noise. The magnitude of those effects may be affected by the frequency, periodicity, duration, and intensity of the sounds, as well as the behavior of the animals during the exposure.

Compared with other species such as marine mammals, little is known about the role of sound and hearing in sea turtle survival or the effects of human-caused noise. However, the results of various investigations indicate that sea turtles are most sensitive to low-frequency sounds. Best sensitivities were found from 200 to 700 Hz for the green turtle (Ridgway et al., 1969) and around 250 Hz or below for juvenile loggerheads (Bartol, 1999). The effective hearing range for marine turtles is generally considered to be between 30 and 2,000 Hz, with a range of maximum sensitivity between 100 and 800 Hz (Bartol, 1999; Ridgway, 1969; Lenhardt, 1994; Bartol and Ketten, 2006; Lenhardt, 2002). Hearing below 80 Hz is less sensitive but still potentially usable (Lenhardt, 1994). Additionally, calculated in-water hearing thresholds at best frequencies (100 to 1,000 Hz) appear to be high, at 160 to 200 dB re 1 μPa (Lenhardt, 1994). A study on the effects of airguns on sea turtle behavior also suggests that they are most likely to respond to low-frequency sounds (McCauley et al., 2000). Green and loggerhead turtles noticeably increased their swimming speed, as well as swimming direction, when received levels reached 166 dB re 1 μPa, and their behavior became increasingly erratic at 175 dB re 1 μPa (McCauley et al., 2000). There is no information regarding the long-term consequences of these disturbances, but short-term disruption in normal behaviors and temporary abandonment of habitat is likely in response to some sounds produced during Long Range Strike WSEP missions.

Similar to the assessment of detonation effects on marine mammals, three sources of information are necessary for estimating potential pressure and acoustic effects on sea turtles: (1) the zone of influence, or the distance from the explosion to which particular levels of impact would extend; (2) the density of animals within the zone of influence; and (3) the number of detonations (events). These components are further detailed below. A description of the acoustic modeling methodology used to determine the number of sea turtles potentially impacted by Long Range Strike WSEP activities is provided in Appendix A. Acoustic and pressure effects are evaluated only for detonations occurring at and beneath the water surface. In-air detonations are not included in impacts analysis because of the negligible transmission of energy and pressure across the air/water interface.

Zone of Influence

The zone of influence is defined as the area or volume of ocean in which sea turtles could be exposed to various pressure or acoustic energy levels caused by exploding ordnance. Until recently, there were no acoustic energy or pressure impact thresholds defined specifically for sea turtles, and in the absence of such information, the thresholds used for marine mammal analysis were typically applied. Although marine mammal criteria continue to be applied where turtle-specific information is absent, NMFS has recently endorsed some sea turtle criteria and thresholds for impulsive sources (including detonations) to be used in impact analysis. Similar to marine mammal analysis, criteria and thresholds are provided for mortality (extensive lung injury), nonlethal injury (slight lung injury or GI tract injury), onset of PTS and TTS, and behavioral effects. Each of these metrics is described below and summarized in Appendix A. Refer to Appendix A for a more detailed description of the acoustic modeling methods used to estimate sea turtle impacts.

<u>Onset of Mortality and Slight Lung Injury</u>

The most commonly reported internal bodily injury to sea turtles resulting from explosive detonations is hemorrhaging in the fine structure of the lungs. The likelihood of internal bodily injury is related to the received impulse of the underwater blast (pressure integrated over time), not peak pressure or energy (Richmond et al., 1973; Yelverton and Richmond, 1981; Yelverton et al., 1973; Yelverton et al., 1975). Therefore, impulse is used as a metric by which internal organ injury can be predicted. Onset mortality and onset slight lung injury are defined as the impulse level that would result in 1 percent mortality (most survivors have moderate blast injuries and should survive) and 0 percent mortality (recoverable, slight blast injuries) in the exposed population, respectively. Criteria for onset mortality and onset slight lung injury were developed using data from explosive impacts on mammals (Yelverton and Richmond, 1981).

The impulse required to cause lung damage is related to the volume of the lungs, which in turn is related to the size (mass) of the animal and compression of gas-filled spaces at increasing water depth. Turtles have relatively low lung volume to body mass and a relatively stronger anatomical structure compared to mammals. Therefore, application of the criteria derived from studies of impacts on mammals is likely conservative.

Table 3.8-11 provides an estimated conservative body mass for each sea turtle species, based on juvenile mass. Juvenile body mass is used due to the early rapid growth (newborn turtles weigh less than 0.5 percent of maximum adult body mass). Scaling of lung volume to depth is conducted for all species because data come from experiments with terrestrial animals held near the water's surface. The calculation of impulse thresholds consider depth of the animal to account for compression of gas-filled spaces that are most sensitive to impulse injury. The impulse required for a specific level of injury is assumed to increase with depth (Goertner, 1982).

Table 3.8-11. Sea Turtle Masses Used to Determine Onset of Mortality and Slight Lung Injury

Species	Juvenile Mass (kg)	Information Source
Loggerhead sea turtle	8.4	Southwood et al., 1999
Green sea turtle	8.7	Wood and Wood, 1993
Hawksbill sea turtle	7.4	Okuyama et al., 2010
Olive ridley sea turtle[1]	6.3	McVey and Wibbles, 1994; Caillouet et al., 1995
Leatherback sea turtle	34.8	Jones, 2009

1. Mass based on the Kemp's ridley turtle, a similar species; kg = kilograms

Onset of Gastrointestinal Tract Injury

In the absence of turtle-specific information, data from tests with terrestrial animals are used to predict onset of GI tract injury. In previous studies, gas-containing internal organs, such as the lungs and intestines, were the principal damage sites from shock waves in submerged terrestrial mammals (Clark and Ward, 1943; Greaves et al., 1943; Richmond et al., 1973; Yelverton et al., 1973). In addition, slight injury to the GI tract may be related to the magnitude of the peak shock wave pressure over the hydrostatic pressure and would be independent of the animal's size and mass (Goertner, 1982). Slight contusions to the GI tract were reported during small charge tests (Richmond et al., 1973), when the peak was 237 dB re 1 μPa. Therefore, this value is used to predict onset of GI tract injury in sea turtles exposed to explosions.

Temporary and Permanent Hearing Threshold Shift

Animals generally do not hear equally well across their entire hearing range. As discussed previously, numerous studies indicate that sea turtles are most sensitive to low-frequency sounds, although sensitivity may vary slightly by species and age class. Because hearing thresholds are frequency-dependent, an auditory weighting function was developed for sea turtles (turtle-weighting, or T-weighting). The T-weighting function simply defines lower and upper frequency boundaries beyond which sea turtle hearing sensitivity decreases. The single frequency cutoffs at each end of the frequency range where hearing sensitivity begins to decrease are based on the most liberal interpretations of sea turtle hearing abilities (10 Hz and 2 kHz). These boundaries are precautionary and exceed the demonstrated or anatomy-based hypothetical upper and lower limits of sea turtle hearing. The T-weighting function adjusts the received sound level, emphasizing frequencies to which sea turtles are most sensitive and reducing emphasis on frequencies outside of their estimated useful range of hearing.

To date, no known data are available on potential hearing impairments (TTS and PTS) in sea turtles. Based on best available science regarding TTS generally in marine vertebrates (Finneran et al., 2005; Finneran et al., 2000; Finneran et al., 2002; Nachtigall et al., 2003; Nachtigall et al., 2004; Schlundt et al., 2000), the respective total T-weighted SEL of 172 dB re 1 μPa^2-s or peak pressure of 224 dB re 1 μPa (23 psi]) is used to estimate exposures resulting in TTS for sea turtles. Onset of PTS levels for these animals is estimated by adding 15 dB to the SEL-based TTS threshold and adding 6 dB to the peak pressure-based thresholds. These relationships were derived by Southall et al. (2007) from impulsive noise TTS growth rates in chinchillas. This results in onset of PTS thresholds of total weighted SEL of 187 dB re 1 μPa^2-s or peak pressure of 230 dB re 1 μPa for sea turtles.

Behavioral Response

A sea turtle's behavioral responses to sound are assumed to be variable and context specific. Most responses would likely be short-term avoidance reactions. A few studies investigated behavioral responses of sea turtles to impulsive sounds emitted by airguns (McCauley et al., 2000; Moein Bartol et al., 1995; O'Hara and Wilcox, 1990). Overall, the studies indicate that perception and a behavioral reaction to a repeated sound may occur with sound pressure levels greater than 166 dB re 1 μPa root mean square and that more erratic behavior and avoidance may occur at higher thresholds around 175 to 179 dB re 1 μPa root mean square. A received level of 175 dB re 1 μPa root mean square is more likely to be the point at which avoidance may occur (McCauley et al., 2000). Currently, an unweighted level (not peak level) of 175 dB re 1 μPa root mean square is considered to be the applicable behavioral threshold level.

Sea Turtle Density

The number of sea turtles potentially affected by detonations may be considered in terms of density, which is the number of animals present in the area affected by a detonation. Similar to the discussion of marine mammals, a significant amount of effort is required to collect and analyze survey data sufficient for producing useable marine species density estimates. As a result, there is often no single source of density available for every area, species, and season of interest. The sea turtle density estimate used in this document is taken from the U.S. Navy's Pacific Marine Species Density Database (DoN, 2014), which includes a compilation of the best available density data.

As discussed in DoN (2014), in-water occurrence data for sea turtles are severely limited. Although tagging studies have been conducted, there is typically little information on occurrence beyond beach areas. Many studies assess turtle abundance by counting nesting individuals or number of eggs or by recording by-catch. Generally, in-water densities cannot be adequately estimated from such information. Accordingly, density estimates for the HRC are derived entirely from Navy data obtained through dive surveys and projects associated with Integrated Natural Resource Management Plans. Due to the relative scarcity of some species and the lack of density estimates for sea turtles associated with open ocean habitats such as the BSURE area, all sea turtle species are combined into a single guild, termed "Pacific Sea Turtles," for purposes of impacts assessment. This group theoretically encompasses all five species with potential occurrence in the Study Area, although only green and hawksbill sea turtles are known to have been observed in the HRC by Navy divers and contractors. Loggerhead, leatherback, and olive ridley turtles could conceivably pass through the area during migration, but the Navy considers the likelihood of occurrence to be extremely low. Nevertheless, these species are included in the guild and assumed to have some potential for occurrence.

Turtles have primarily been observed by Navy divers and contractors within the 100-meter isobath (and usually much shallower than 100 meters) around the islands of Kauai, Lanai, Molokai, and Oahu, and density values have been directly calculated only within this depth contour. Densities beyond this depth in the open ocean are expected to be substantially less. For areas of the HRC outside the 100-meter isobath, the Navy used the mean density around the islands reduced by two orders of magnitude. The Navy applied a density correction factor to account for diving turtles and turtles that were at the surface but not seen by observers. Specifically, it was estimated that only 10 percent of the turtles actually present were seen. Density estimates used for acoustic analysis are provided in the associated Biological Assessment (Appendix A).

Number of Events

As discussed in the marine mammal impacts analysis, an "event" refers to a single, unique action that has the potential to expose sea turtles to various pressure and/or sound levels. The number of events generally corresponds to the number of live ordnance items released within a 24-hour period. For 2016 missions, all live ordnance is proposed to be released on the same mission day, which would equate to a single event with multiple releases. As described in the marine mammals section, up to four SDBs may be released simultaneously and detonate as a burst. One single JASSM/JASSM-ER release and two SDB bursts are proposed for 2016. The total energy for all releases is summed for impact calculations, but the pressure component is not. For 2017–2021, the exact number and types of munitions that would be released each day is not known and would vary. To account for total annual impacts, the total number of each munition proposed to be released per year was divided by five (annual number of mission days), and that number was treated as a representative mission day. As with the 2016 missions, the total energy for all weapon releases in a typical mission day is summed for impact calculations. Five mission days per year are planned during the time frame of 2017–2021. Refer to the acoustic modeling appendix of the associated Biological Assessment (Appendix A) for a detailed explanation of modeling methods.

Exposure Estimates

The maximum estimated range, or radius, from the detonation point to which the various thresholds extend was calculated based on acoustic modeling methods described in the associated regulatory consultation documents (Appendix A). The ranges were used to calculate the total area of the zones of influence, which were then combined with density estimates and the number of events to provide an estimate of the number of sea turtles potentially exposed to the various impact thresholds. For metrics with two thresholds (e.g., 187 dB SEL and 230 dB SPL for onset PTS), the criterion that results in the higher exposure estimate is used for impact calculations. Exposure estimates do not take into account the required mitigation and monitoring measures described in Chapter 5.

Missions Conducted in 2016

Similar to the discussion in the marine mammal section, potential impacts resulting from detonations are presented separately for the first year of testing (2016) and for the following five years. Immediate evaluations for the JASSM/JASSM-ER and SDB-I/II are needed for a smaller number of munitions in 2016 as compared to 2017–2021. Weapon release parameters would involve the release of one live JASSM and up to eight live SDB munitions in bursts of four. All weapons would detonate upon impact with the water surface. The resulting total number of sea turtles potentially affected is shown Table 3.8-12. The numbers represent total impacts for all detonations combined. For some thresholds, exposure calculations from the model output resulted in decimal values, suggesting that a fraction of an animal was exposed. In these cases, the model results were rounded to the nearest whole number. Abundance, distribution, and density information was not sufficient to estimate exposures by species; numbers presented in the table are for all five species combined.

Table 3.8-12. Number of Sea Turtles Potentially Affected by Long Range Strike WSEP Missions Proposed for 2016 Under Alternative 1 (Preferred Alternative)

Species	Mortality	Slight Lung Injury	Slight GI Tract Injury	PTS	TTS	Behavioral
Sea turtle species (all five species combined)	0	0	0	0	1	0

WSEP = Weapon Systems Evaluation Program

The table indicates the potential for a total of one TTS exposure for sea turtles. It is likely that this exposure would be associated with either a green or hawksbill sea turtle. There would be no impacts to sea turtles associated with mortality, injury, permanent hearing effects, or behavioral effects. Exposure calculations do not take into account the mitigation measures described in Chapter 5, which may reduce the potential for effects.

Missions Conducted from 2017 to 2021

As stated previously, proposed munition releases for 2017–2021 missions are greater than what is proposed for 2016 missions. The resulting number of sea turtles potentially impacted under the various levels of thresholds is listed in Table 3.8-13. Exposure calculations resulted in decimal values, suggesting in most cases that a fraction of an animal was exposed. To eliminate this, the model results were rounded to the nearest whole animal. In addition, to eliminate “double-counting” of animals, exposure results from higher impact categories (e.g., mortality) were subtracted from lower impact categories (e.g., slight lung injury). The numbers represent total impacts for all detonations combined per year. Abundance, distribution, and density information was not sufficient to estimate exposures by species; numbers presented in the table are for all five species combined.

Table 3.8-13. Annual Number of Sea Turtles Potentially Affected by Long Range Strike WSEP Missions Proposed for 2017-2021 Under Alternative 1 (Preferred Alternative)

Species	Mortality	Slight Lung Injury	Slight GI Tract Injury	PTS	TTS	Behavioral
Sea turtle species (all five species combined)	0	0	0	1	15	0

GI = gastrointestinal; PTS = permanent threshold shift; TTS = temporary threshold shift; WSEP = Weapon Systems Evaluation Program

Modeling results indicate the potential for permanent and temporary hearing effects in the absence of mitigation measures. The mitigation and monitoring requirements described in the associated Biological

Assessment (Appendix A) and in Chapter 5 would potentially afford some protection for sea turtles. Observers would look for turtles as well as other protected marine species during pre- and post-mission surveys. In most cases it would not be possible to track a turtle that is sighted and then submerges.

Available literature suggests that sea turtles are most likely to respond to low frequency sounds. Observations of turtles in the vicinity of airgun operations, which produce broadband noise including low frequency signals (similar to underwater explosions), indicate that individuals increase swimming activity at received levels between 166 and 175 dB re 1 µPa and exhibit more pronounced behavior changes such as erratic movements and increased diving at higher received levels (McCauley et al., 2000; DeRuiter and Larbi Doukara, 2012). Although it is possible that sea turtles in the vicinity of an in-water detonation might experience a temporary or permanent hearing threshold shift, it is not known what energy levels and received levels are necessary to induce threshold shifts. (TTS and PTS thresholds are estimated based on general marine vertebrate hearing effects.) Overall, the Air Force considers that Long Range Strike WSEP missions are not likely to interact with a sufficient number of sea turtles to reduce the reproduction, population numbers, or distribution of any species.

Conclusion

Pursuant to the ESA, the Air Force has determined that detonation effects from Long Range Strike WSEP missions proposed for 2016 may affect, but are not likely to adversely affect, ESA-listed sea turtle species. The Air Force has also determined that detonation effects from Long Range Strike WSEP missions proposed for 2017–2021 may affect, and are likely to adversely affect, individuals of ESA-listed sea turtle species. Impacts are most likely to be associated with green and hawksbill sea turtles, as these are the only species commonly reported in offshore portions of the BSURE area. There is a small potential for affected species to include loggerhead, olive ridley, or leatherback sea turtles.

The Air Force has consulted with NMFS under Section 7 of the ESA and received a BO and Incidental Take Statement for 2016 missions on September 29, 2016 (Consultation Number FPR-2016-9160). In the BO, NMFS indicated that the majority of sea turtles within the PMRF would be green sea turtles from the Central North Pacific DPS; therefore, the one instance of TTS from 2016 missions would likely happen to a Central North Pacific DPS green sea turtle. NMFS concluded that Long Range Strike WSEP 2016 missions are not likely to adversely affect hawksbill, loggerhead, olive ridley, and leatherback sea turtles. NMFS also concluded that Long Range Strike WSEP 2016 missions are likely to adversely affect, but will not appreciably reduce, the ability of the Central North Pacific DPS of green sea turtles to survive and recover in the wild and, therefore, are not likely to jeopardize the continued existence of the Central North Pacific DPS of green sea turtles. A Programmatic BO and Incidental Take Statement will be prepared and issued for 2017–2021 Long Range Strike WSEP activities before missions commence in 2017.

Based on the information provided above, including a description of sea turtle species with potential occurrence in the study area, the potential number and types of take, and adherence to the mitigation measures described in Chapter 5, the Air Force concludes there would likely be no population-level effects to sea turtle species. Therefore, there would be no significant impacts to sea turtles resulting from Long Range Strike WSEP missions.

3.8.3.2.3 Marine Fish

Marine fish could potentially be impacted by noise or pressure resulting from detonations, ingestion of military expended materials, and alteration of water and sediment quality. Detonation effects would be possible for fish relatively close to the impact point, while military expended materials and water quality alteration could affect fish farther from the mission site. Each type of potential effect is discussed below. Physical impacts to the seafloor resulting from explosions would not occur due to water depth and, therefore, there would be no effects to benthic fish habitat, such as sediment displacement or seafloor cratering, resulting from weapons testing.

Detonation Effects

Detonations at or below the water surface may generate overpressure (shock waves) and sound that move through the water column for some distance. The resulting effects to marine species such as fish could include blast injury, barotrauma, hearing effects, and stress or behavioral reactions. *Blast injury* refers to injuries resulting from compression of a fish's body when exposed to a shock wave, while *barotrauma* refers to injuries caused when gas-filled structures, such as the swim bladder, vibrate in response to a blast. A shock wave produces a sudden, intense change in pressure that can tear body tissues and cause rupture or hemorrhage in various internal organs (Wright, 1982; Lewis, 1996). Therefore, shock waves are often lethal to fish near the detonation (Continental Shelf Associates, 2004). At greater distance from the detonation point, the extent of mortality or injury depends on a number of factors such as fish size, body shape, and orientation in the water column (e.g., Keevin and Hempen, 1997; Lewis, 1996; O'Keeffe and Young, 1984; Wright, 1982). Underwater topography and water depth may also affect the potential for impact. In addition, the expanding gases resulting from a detonation can set up a pulsating bubble whose recurring pressure waves also may contribute significantly to damage. Many animals, especially smaller animals, are unlikely to survive if they are present in the region of cavitation. Cavitation occurs when shock waves, which are generated by the underwater detonation of an explosive charge, propagate to the surface and are reflected back into the water as negative pressure waves.

Military researchers have previously developed models to predict safe ranges for fish of various sizes (e.g., Young, 1991; O'Keeffe and Young, 1984). Young (1991) provides an equation that allows estimation of the potential effects of underwater detonations to fish with swim bladders (some fish species such as sharks do not possess swim bladders). Table 3.8-14 shows mortality ranges, based on the equation, for the one munition that would be detonated underwater (JDAM/LJDAM). The 10 percent mortality range is the distance beyond which 90 percent of fish would be expected to survive. Noise and pressure levels resulting from surface detonations would be less than those associated with underwater detonations. Therefore, while not quantified, the distance to which mortality and other effects would occur as a result of surface detonations is substantially less.

Table 3.8-14. Estimated Mortality Ranges for Fish with Swim Bladders

Representative Munition	Net Explosive Weight (pounds)	Depth of Explosion (feet)[1]	10 Percent Mortality Range (feet)	
			1-Pound Fish	30-Pound Fish
JDAM/LJDAM	192	10	687	442

JDAM = Joint Direct Attack Munition; LJDAM = Laser Joint Direct Attack Munition
1. Subsurface detonations are assumed to occur at a depth of 10 feet.

Although the extent to which Young's equation applies to actual conditions in the BSURE is uncertain, the table illustrates the potential for fish located within several hundred feet of an underwater detonation to be killed. The number of fish affected would depend on the local population density at the time of detonation, in addition to other factors such as fish size and position in the water column. Variations in fish abundance, distribution, and distance from the detonation point make it very difficult to predict the actual number of fish affected at any specific site. Experiments that investigate potential mortality related to underwater noise have been conducted for only a few species. Bolle et al. (2012) exposed common sole (*Solea solea*) larvae to pile-driving sound levels (another type of impulsive underwater sound somewhat similar to detonations) of up to 206 dB re 1 μPa^2-s cumulative SEL and 210 dB re 1 μPa^2 zero-to-peak SPL. No statistically significant differences in mean mortality were found between control and experimental groups for any larval stage. However, the applicability of this study to other species and life stages is unknown.

Most fish species experience large numbers of natural mortalities, and a relatively small level of additional mortality caused by WSEP missions would not be expected to result in population-level effects for any species. Many missions involve inert munitions or detonation of live munitions in the air or at the water surface (see Table 2.2-1 and Table 2.2-2). These scenarios would result in less potential for mortality. Missions involving underwater detonations would be spread over time. Generally, it is not expected that large numbers of fish would be killed as a result of underwater detonations under the Proposed Action or that any population would be significantly affected. As a reference point, monitoring during the shock trial of the Navy destroyer *USS John Paul Jones*, in which a 10,000-pound charge was detonated underwater, documented about 100 dead fish (presumably at the surface; underwater surveys were not reported) (DoN, 1998).

Potential injuries to fish may be considered separately from mortality. There are currently no generally accepted injury criteria specifically for detonations, but Stadler and Woodbury (2009) discuss criteria for injuries potentially resulting from pile driving. The criteria were developed by state and federal agencies and used by NMFS to estimate impacts in marine environments. The onset of physical injury is assumed when either the peak sound pressure level exceeds 206 dB re 1 μPa or the cumulative SEL (accumulated over a day) exceeds 187 dB re 1 $\mu Pa\text{-}s^2$. More recent investigation (National Cooperative Highway Research Program, 2011) has resulted in different criteria to estimate injury (barotrauma) caused by pile driving. The authors suggest an exposure threshold of 179 to 181 dB re 1 $\mu Pa^2\text{-}s$ (depending on the number of strikes) combined with a cumulative SEL of 211 dB re 1 $\mu Pa^2\text{-}s$ over the duration of the pile driving event. It is anticipated that these levels would cause no more than mild, non-life-threatening injuries. There is some potential for marine fish to be affected by detonations. However, as described in the discussion of mortality potential, relatively few mission scenarios involve underwater detonation of live munitions, and such events would be spread out over time. The number of fish potentially injured would depend on local fish density at the time of the detonation, in addition to various other factors, and would be difficult to estimate. Similar to the preceding discussion, injury caused by long range strike WSEP missions would not likely affect overall fish populations.

Similar to other types of marine animals, exposure to high-intensity sound can cause hearing threshold shifts in fish. A threshold shift occurs when intense sound causes damage to the auditory system, resulting in a shift in the sound level that can be heard at a given frequency. That is, at the affected frequency, sound must be louder to be heard compared with the hearing ability before the shift. Such a shift may be temporary or permanent. Popper and Hastings (2009) provide a review of studies relevant to hearing shifts in fish due to impulsive noise (primarily from use of airguns). One study examined the effects of an airgun array on a fish species with hearing specializations and two species that lack specializations. The results showed temporary hearing loss for two of the species. Another study described loss of a small percentage of sensory hair cells in pink snapper (*Pagrus auratus*) exposed to a moving airgun array for 1.5 hours. In a third study, investigators exposed various fish species to an airgun array at various distances from the acoustic source. The authors found no resulting hearing loss in any fish. Popper and Hastings (2009) caution that extrapolating the results of these or other studies to different environments, acoustic events, or fish species may not be valid. However, it may be reasonably considered that some number of fish occurring close to an underwater detonation could experience temporary or permanent hearing threshold shifts. It is not expected that the number of fish potentially affected would result in adverse effects to overall fish populations.

At distances beyond which mortality, injury, or hearing effects would be expected, underwater sound could result in stress reactions or behavioral responses in fish. A limited number of studies have shown or suggested noise-induced stress response in some fish species (e.g., Smith et al., 2004; Wysocki et al., 2006; Popper and Hastings, 2009; Debusschere et al., 2015). Sound exposure may cause altered behavior and physiological effects such as changes in hormone levels or respiration in some species. Behavioral effects could include disruption of activities such as swimming, schooling, feeding, breeding, or migrating. Sudden sounds could also cause fish to dive, rise, or change swimming direction. Although some fish in the vicinity of test events could react negatively to the sound of underwater or surface detonations, the sounds would be relatively short term and localized. Behavioral changes are not expected to have lasting effects on the survival, growth, or reproduction of fish populations.

There would be no significant impacts to marine fish from detonation effects associated with Long Range Strike WSEP missions.

Ingestion Effects

Military expended materials such as small fragments of exploded munitions could sink to the seafloor and be ingested by fish that forage for food items on or within the substrate. Similarly, floating pieces of debris resulting from target strikes, such as small fiberglass or plywood particles from target boats, could be ingested by fish that feed at the water surface. Overall, the potential for ingesting military expended materials would be limited to individual fish that might consume an item and experience a negative (injurious) effect. While ingestion of expended materials could result in lethal or sub-lethal effects to a small number of individuals, the likelihood of a fish encountering an expended item is low based on the dispersed nature of the materials. Furthermore, an encounter may not lead to ingestion, and ingestion would not necessarily cause injury. The number of fish potentially impacted would be low compared with overall population numbers, and population-level effects would not be expected.

There would be no significant impacts to marine fish from ingestion effects resulting from Long Range Strike WSEP missions.

Water Quality and Sediment Quality Effects

Fish could potentially be impacted due to degradation of water and sediment quality resulting from deposition of chemical materials and metals. Chemical materials and metals would enter the water column in the form of explosive material, detonation byproducts, and metals from munitions casings and fragments. However, as detailed in Section 3.8.3.2.4 (*Essential Fish Habitat*) below, these materials would have an overall negligible effect on water and sediment quality and would not result in degradation of the physical marine environment. No effects to the health or viability of fish populations or individuals would be expected.

There would be no significant impacts to marine fish from water quality and sediment quality effects resulting from Long Range Strike WSEP missions.

3.8.3.2.4 Essential Fish Habitat

The MSA requires federal agencies to assess potential impacts to EFH for managed commercial fisheries. Adverse impacts to EFH are defined as those that reduce quality and/or quantity of this habitat. EFH designated by the WPRFMC is identified in Section 3.8.2.4 of this document. EFH is present within the northern portion of the BSURE area for some but not all management units/life stages, as summarized below.

Bottomfish. Bottom habitat EFH for adults and juveniles generally extends from the shore to a maximum water depth of 400 meters (for deep-slope species) but also includes an area to 600 meters deep for seamount species. Water depth at the Long Range Strike WSEP impact area is approximately 4,600 meters, which is beyond the EFH boundary for adult and juvenile life stages. The mission area does not coincide with the deeper seamount species area. EFH for the eggs and larvae of deep-slope species includes the water column from the shoreline to the EEZ boundary. Therefore, this EFH component is present in the study area.

Crustaceans. Adult and juvenile bottom habitat EFH is not present in the northern BSURE area because of the water depth (maximum depth of 100 meters). However, similar to the bottomfish management unit, egg and larvae EFH for lobsters includes the water column from the shoreline to the EEZ boundary.

Precious corals. None of the identified precious coral beds occur within the study area. The nearest is a black coral bed located near the southern shore of Kauai.

Coral reef ecosystems. EFH for adult and juvenile life stages of currently harvested and potentially harvested corals generally includes bottom habitat to a depth of 50 fathoms (91 meters). Water depth at the Long Range Strike WSEP mission area is approximately 4,600 meters, which is beyond this boundary. EFH for eggs and larvae (and other life stages in a few instances) of currently harvested corals and all life stages of potentially harvested corals consists of the water column from the shoreline to the EEZ boundary. Therefore, this EFH component is present in the study area.

Pelagic fishery. Pelagic species EFH consists of the water column from the shoreline to the EEZ boundary. Therefore, this EFH component is present in the study area.

HAPCs. No HAPCs are present at the WSEP mission area for any management unit.

In summary, EFH in the WSEP mission area consists of the water column, from the surface to varying depths (maximum depth of 1,000 meters). The impact area is located well beyond seafloor EFH, and the potential for expended items to be moved into designated bottom habitat by water currents is considered negligible. Water quality in the BSURE area is considered excellent, as land-based runoff and effluent is generally confined to the neritic zone near the shoreline (DoN, 2008). Water depth increases quickly from the Kauai shoreline, and the open ocean around the Hawaiian Islands generally has high water clarity, low quantities of suspended materials, and low concentrations of trace metals and hydrocarbons. The coastal current system around the Hawaiian Islands has a strong flow and exchange with offshore waters, diluting and dispersing sediment and pollutants. Offshore water patterns are characterized by large-scale currents, deep eddies, storm swells, and wind swells. Impacts to the water column could occur due to physical disturbance, military expended materials, and the introduction of metals, explosive material, explosion byproducts, and other chemical materials. Each of these effector categories is discussed below.

Physical Disturbance

Explosions associated with Long Range Strike WSEP missions would occur at or near the water surface and would, therefore, not disturb the substrate. However, the shock wave resulting from an explosion could affect the pelagic water column, which is habitat for the eggs and larvae of numerous managed species, as well as for adult and juvenile stages of pelagic fish and squid. As discussed in Section 3.8.3.2.3, *Marine Fish*, shock waves and cavitation in the water can cause mortality and injury to fish, including managed species, in the vicinity of an explosion. Invertebrates such as squid could be impacted as well. Although the number of individuals potentially affected is difficult to estimate due to variability in the local population density at the time of detonation, animal size, and position in the water column, detonations are not expected to have lasting effects on the survival, growth, or reproduction of any fish or invertebrate population. No substantial impacts to water column EFH resulting from physical disturbance are expected.

Military Expended Materials

Military expended materials potentially generated during Long Range Strike WSEP missions include inert munitions and fragments of exploded bombs and missiles. A small number of items may float on the water surface or in the water column for some time period, but most military expended materials would quickly sink to the ocean floor. Floating or sinking items would not physically alter the water in any meaningful or lasting manner and, therefore, would not adversely impact to the water column itself.

Metals

Various metals would be introduced into the water column through expended munitions. The casings, fins, and other parts of large munitions such as bombs and missiles are typically composed primarily of steel but usually also contain small amounts of lead, manganese, phosphorus, sulfur, copper, nickel, and several other metals (DoN, 2013). Aluminum is also present in some explosive materials such as PBXN. Many metals occur naturally in seawater at varying concentrations and some, such as aluminum, would not necessarily be detrimental to the water column. However, some metals, such as lead, may be toxic in high concentrations.

Munitions and other metal items would sink to the seafloor and would typically undergo one of three processes: (1) enter the sediment where there is reduced oxygen content, (2) remain exposed on the ocean floor and begin to react with seawater, or (3) remain exposed on the ocean floor and become encrusted with marine organisms. The rate of deterioration would, therefore, depend on the specific composition of an item and its position relative to the seafloor/water column. Munitions located deep in the sediment would typically undergo slow deterioration. Some portion of the metal ions would become bound to sediment particles. Metal materials exposed to seawater would begin to slowly corrode. This process typically creates a layer of corroded material between the seawater and metal, which slows the movement of metal ions into the adjacent water column. A similar process would occur with munitions that become covered by marine growth. Direct exposure to seawater would be reduced, thereby decreasing the rate of corrosion.

Metal particles that migrate into the water column would be diluted by diffusion and the water movements typical of the open ocean environment around the Hawaiian Islands. Therefore, elevated concentrations would not be expected in any area. This expectation is supported by the results of two U.S. Navy studies related to munitions use and water quality, as summarized in DoN (2013). In one study, water quality sampling for lead, manganese, nickel, vanadium, and zinc was conducted at a shallow bombing range in Pamlico Sound off North Carolina immediately following a bomb training event with inert practice munitions. With the exception of nickel, all water quality parameters tested were within the state limits. The nickel concentration was substantially higher than the state criterion, although the concentration did not differ significantly from a control site located outside the bombing range. This suggests that bombing activities may not have been responsible for the elevated nickel concentration. The second study, conducted by the U.S. Marine Corps, included sediment and water quality sampling for 26 munitions constituents at multiple water training ranges. Metals included lead and magnesium. No levels were detected above screening values used at the water ranges.

Explosives and Explosion Byproducts

Explosives are complex chemical mixtures that may affect water quality through the byproducts of their detonation and the distribution of unconsumed explosives. Some of the more common types of explosive materials used in WSEP missions include tritonal and PBX. Tritonal is primarily composed of TNT, and PBX may be combined with RDX. Discussion in the remainder of this subsection will, therefore, consider TNT and RDX to be representative of all explosives.

During detonation, energetic compounds may undergo high-order (complete) detonation or low-order (incomplete) detonation. In addition, the compounds may fail to detonate altogether. High-order detonations consume almost all of the explosive material, with the remainder released into the environment as discrete particles. Analysis of live-fire detonations on terrestrial ranges have indicated that over 99.9 percent of TNT and RDX explosive material is typically consumed during a high-order detonation (Hewitt et al., 2003). Pennington et al. (2006) reported a median value of 0.006 percent and 0.02 percent for TNT and RDX residue, respectively, remaining after detonation. The total NEW for all combined munitions for all years of testing is 49,646 53,010 pounds. Dividing this number by five years (the time frame over which most of the weapons will be tested) results in a yearly use 10,602 pounds of explosive material. Using the more conservative (higher) value of 0.02 percent for residual material, a total of about 2.1 pounds of explosive material could be deposited annually into the open ocean north of Kauai. For purposes of analysis, it may be assumed that all residual materials are deposited simultaneously and remain within the BSURE area, and within the top 10 feet of the water column (10 feet is the maximum detonation depth scenario for any munition). In this case, the resulting concentration of explosive material in the BSURE would be about 1×10^{-13} milligrams per liter (mg/L). In reality, the materials would be deposited incrementally over time and would eventually be dispersed throughout a larger surface area and water volume by water movement. Although there are no state or federal water quality standards applicable to the target area (about 44 NM offshore), this value may be compared to the DoD Range and Munitions Use working group marine screening value for the amount of

C-4 (another type of explosive composed of mostly RDX) remaining after detonation (as provided in U.S. DoN, 2013). The screening value is 5 mg/L, which is many orders of magnitude greater than the concentration calculated above.

Various byproducts are produced during and immediately after detonation of explosives such as TNT and RDX. During the brief time that a detonation is in progress, intermediate products may include carbon ions, nitrogen ions, oxygen ions, water, hydrogen cyanide, carbon monoxide, nitrogen gas, nitrous oxide, cyanic acid, and carbon dioxide (Becker, 1995). However, reactions quickly occur between the intermediates and surrounding water, and the final products consist mainly of carbon (i.e., soot), carbon dioxide, water, carbon monoxide (CO), and nitrogen gas (Naval Surface Warfare Center, 1975). These substances are natural components of seawater. Other products, occurring at substantially lower concentrations, include hydrogen, ammonia, methane, and hydrogen cyanide, among others.

After detonation, the residual explosive materials and detonation byproducts would ultimately be dispersed throughout the central Pacific Ocean by diffusion and by the action of wind, waves, and currents. A portion of the carbon compounds, such as carbon monoxide and carbon dioxide, would likely become incorporated into the carbonate system (alkalinity and pH buffering capacity of seawater). Some of the nitrogen and carbon compounds would be metabolized or assimilated by phytoplankton and bacteria. Most of the gas products that do not react with the water or become assimilated by organisms would be released to the atmosphere. Given that the residual concentration of explosive material would be small, most of the explosion byproducts would be harmless or natural seawater constituents, and byproducts would dissipate or be quickly diluted, impacts to water quality resulting from high-order detonations would be negligible.

Low-order detonations consume a lower percentage of the explosive and, therefore, a portion of the material is available for release into the environment. If the ordnance fails to detonate, the entire amount of energetic compound remains largely intact and is released to the environment over time as the munition casing corrodes. The likelihood of incomplete detonations is not quantified; however, the portion of munitions that could fail to detonate (i.e., duds) has been estimated at between about 3 and 5 percent (Walsh, 2007; Rand Corporation, 2005). Based on a potential dud rate of 5 percent, the number of live munitions, and NEW in each munition, it is estimated that about 2,482 pounds of explosive material (TNT and RDX, among others) could enter the BSURE area through unexploded munitions over the total testing time frame, or 496 pounds per year assuming a five-year project. However, most of this material would not be available in the marine environment immediately. Explosive material would diffuse into the water through screw threads, cracks, or pinholes in the munition casings. Therefore, movement of explosive material into the water column would likely be a slow process, potentially ranging from months to decades.

After leaving the munition casing, explosive material would enter the sediment or water column. Similar to the discussion of explosive byproducts above, chemical materials in the water column would be dispersed by currents and would eventually become uniformly distributed throughout the central Pacific Ocean. Explosive materials in the water column would also be subject to biotic (biological) and abiotic (physical and chemical) transformation and degradation, including hydrolysis, ultraviolet radiation exposure, and biodegradation. TNT is rapidly degraded in marine environments by biological and photochemical processes (Walker et al., 2006). Marine ecosystems are generally nitrogen-limited compared with freshwater systems, and marine microbes such as bacteria may therefore readily use TNT metabolites (e.g., ammonia and ammonium). TNT that is not biodegraded may sorb (bind to by absorption or adsorption) onto particulates, break down into dissolved organic matter, or dissolve into the water column. TNT is also subject to photochemical degradation, known as photolysis, whereby the ultraviolet component of sunlight degrades the compound into products similar to those produced by biodegradation. Photolysis is more effective in waters of shallower depth and/or with greater clarity. Uptake and metabolism of TNT has also been noted in phytoplankton. It is assumed that similar processes could affect other explosives such as RDX.

The results of studies of UXO in marine environments generally suggest that there is little overall impact to water quality resulting from the leaching of explosive material. Various researchers have studied an area in Halifax Harbor, Nova Scotia, where UXO was deposited in 1945. Rodacy et al. (2000) reported that explosives signatures were detectable in 58 percent of water samples but that marine growth was observed on most of the exposed ordnance. TNT metabolites, suspected to result from biological decomposition, were also detected. In an earlier study (Darrach et al., 1998), sediment collected near unexploded (but broken) ordnance did not indicate the presence of TNT, whereas samples near intact ordnance showed trace explosives in the range of low parts per billion or high parts per trillion. The authors concluded that, after 50 years, the contents of broken munitions had dissolved, reacted, biodegraded, or photodegraded and that intact munitions appear to be slowly releasing their contents through corrosion pinholes or screw threads.

Hoffsommer et al. (1972) analyzed seawater (as well as sediment and ocean floor fauna) at known munition dumping sites off Washington State and South Carolina for the presence of TNT, RDX, tetryl, and ammonium perchlorate. None of these materials were found in any of the samples. Walker et al. (2006) sampled seawater and sediment at two offshore sites where underwater demolition was conducted using 10-pound charges of TNT and RDX. Residual TNT and RDX were below the detection limit in seawater, including samples collected in the plume within five minutes of detonation.

More recently, Smith and Marx (2016) investigated the Farallon De Medinilla bombing range in the Mariana Archipelago. The range has been used for live and inert firing and bombing since 1971. An undetermined quantity of UXO is present at the site. A total of 14 underwater surveys were conducted to evaluate physical conditions (e.g., craters, broken rocks or coral), algae, coral, invertebrates, fish, and sea turtles. Overall, conditions were indicative of a healthy ecosystem, and no evidence was found of adverse impacts to biological resources.

Other Chemical Materials

A small number of plastic component items could be produced by munition detonations. Because of their buoyancy and resistance to degradation, many types of plastic float and may travel long distances in the ocean (U.S. Commission on Ocean Policy, 2004). Plastics may serve as vehicles for transport of various pollutants, whether by binding them from seawater or from the constituents of the plastics themselves. Plastic items would eventually break down into smaller particles due to photolysis and mechanical wear (Law et al., 2010), although even microscale particles may retain the same potential for chemical effects (Setala et al., 2016). However, due to the very small number of plastic items produced and dispersion by wind and water currents, no detectable effects to water quality in the Long Range Strike WSEP mission area are expected.

Summary of Potential Impacts to Essential Fish Habitat

In summary, Long Range Strike WSEP missions in the BSURE area could potentially impact EFH by alteration of water quality through introduction of metals and chemical materials. Explosion byproducts could have temporary and localized effects but would be quickly dispersed and diluted by water currents (on the order of hours to days). Metals and explosives associated with UXO could be present at the mission site for long time periods (years to decades); however, effects to the water column would be limited to a small area around such items. Solid items could become corroded, encrusted, or covered with sediment, and constituents of unconsumed explosives would be subject to several physical, chemical, and biological processes that render the materials harmless or would otherwise dissipate them to undetectable levels. Physical disturbance of the water column would be temporary and would not alter the water in any measurable or lasting manner. Pursuant to the MSA, the Air Force prepared and submitted an EFH Assessment to NMFS on April 19, 2016, and determined that Long Range Strike WSEP missions would not adversely affect EFH. NMFS provided a response letter on May 19, 2016, with five conservation recommendations for the Air Force to consider that would minimize potential adverse impacts to EFH. The Air Force submitted a response to each conservation recommendation in a letter dated June 22, 2016, and supplemental responses in a letter dated August 30, 2016. All agency correspondence is included in Appendix A. There would be no significant impacts to EFH resulting from Long Range Strike WSEP activities under Alternative 1 (Preferred Alternative).

3.8.3.3 Alternative 2

Alternative 2 differs from the Preferred Alternative only in that no underwater detonation of JDAMs would occur during the time period of 2017 to 2021; all detonations would occur at the water surface. All other aspects of Long Range Strike WSEP missions would be the same between the Preferred Alternative and Alternative 2. Therefore, there would be no difference in potential impacts on marine mammals, sea turtles, marine fish, and EFH due to physical strikes, ingestion stressors, or the deposition of military expended materials, metals, explosives, explosion byproducts, or other chemical materials into the water column and substrate under Alternative 2. Therefore, the analysis below focuses on detonation effects to biological resources.

3.8.3.3.1 Marine Mammals

Detonation Effects

The approach to analysis for detonation effects to marine mammals is described in Section 3.8.3.2.1, under Detonation Effects and is similarly applied for assessing impacts under Alternative 2.

Missions Conducted in 2016

As shown in Table 2.2-2, Long Range Strike WSEP missions proposed for 2016 under Alternative 2 would be the same as Alternative 1 (Preferred Alternative), consisting of one live JASSM and eight SDB-I munitions, with four SDB-I releases occurring simultaneously. All weapons would detonate upon impact with the water surface. This level of live weapon releases is much lower than what is proposed for follow-on years, and is therefore analyzed separately. The resulting total number of marine mammals potentially exposed to the various threshold levels is the same as Alternative 1 and is shown in Table 3.8-9.

Based on acoustic modeling, zero marine mammals are estimated to be affected by impulse levels associated with mortality, GI tract injury, or slight lung injury. Approximately one dwarf sperm whale could be exposed to energy levels associated with PTS. Additionally, 9 dwarf sperm whales, 3 pygmy sperm whales, 3 humpback whales, 1 minke whale, and 1 Fraser’s dolphin could experience TTS, and 64 dwarf sperm whales, 26 pygmy sperm whales, 9 humpback whales, and 2 minke whales could experience behavioral effects. None of the estimated exposure numbers take into account the mitigation measures outlined in Chapter 5, which are expected to reduce the number and severity of effects. Potential impacts are not expected to result in long-term population level effects.

Missions Conducted from 2017 to 2021

As shown in Table 2.2-2, Long Range Strike WSEP missions proposed for 2017–2021 under Alternative 2 would consist of up to 6 live JASSM, 30 SDB-I, 30 SDB-II, 10 HARM, and 30 JDAM munitions per year. Under Alternative 2, all weapons, including JDAMs, would detonate at the water surface. The resulting total number of marine mammals potentially exposed to the various threshold levels is shown in Table 3.8-15. Exposure calculations resulted in decimal values, suggesting in most cases that a fraction of an animal was exposed. To eliminate this, the model results were rounded to the nearest whole animal. In addition, to eliminate “double-counting” of animals, exposure results from higher impact categories (e.g., mortality) were subtracted from lower impact categories (e.g., Level A harassment). Exposure levels include the possibility of injury (PTS) and non-injurious harassment (including behavioral harassment) to marine mammals. The numbers represent total impacts for all detonations combined per year and do not take into consideration the implementation of mitigation measures described in Chapter 5.

Table 3.8-15. Annual Number of Marine Mammals Potentially Affected by Long Range Strike WSEP Missions Proposed for 2017-2021 Under Alternative 2

Species	Mortality	Level A Harassment (PTS)	Level B Harassment (TTS)	Level B Harassment (Behavioral)
Mysticetes (baleen whales)				
Humpback whale	0	0	0	0
Blue whale	0	0	0	0
Fin whale	0	0	0	0
Sei whale	0	0	0	0
Bryde's whale	0	0	0	0
Minke whale	0	0	0	0
Odontocetes (toothed whales and dolphins)				
Sperm whale	0	0	0	0
Pygmy sperm whale	0	1	6	7
Dwarf sperm whale	0	2	16	17
Killer whale	0	0	0	0
False killer whale	0	0	0	0
Pygmy killer whale	0	0	0	1
Short-finned pilot whale	0	0	1	0
Melon-headed whale	0	0	0	0
Bottlenose dolphin	0	0	0	0
Pantropical spotted dolphin	0	0	0	1
Striped dolphin	0	0	0	0
Spinner dolphin	0	0	0	0
Rough-toothed dolphin	0	0	0	1
Fraser's dolphin	0	0	1	2
Risso's dolphin	0	0	0	1
Cuvier's beaked whale	0	0	0	0
Blainville's beaked whale	0	0	0	0
Longman's beaked whale	0	0	0	1
Pinnipeds				
Hawaiian monk seal	0	0	0	0
Total	**0**	**3**	**24**	**31**

PTS = permanent threshold shift; TTS = temporary threshold shift

The number of exposures associated with 2017–2021 Long Range Strike WSEP missions for each criterion is lower under Alternative 2 than under Alternative 1. No mortality is calculated under Alternative 2. Level A harassment (PTS) is calculated only for pygmy sperm whale and dwarf sperm whale. Overall impacts would be similar to those described for Alternative 1. Based on the information discussed under Alternative 1, including a description of marine mammal species with potential occurrence in the study area, the potential number and types of take, and adherence to mitigation measures described in Chapter 5, the Air Force concludes there would likely be no population-level effects to any marine mammal species or stock. Therefore, there would be no significant impacts to marine mammals resulting from Long Range Strike WSEP missions.

3.8.3.3.2 Sea Turtles

Detonation Effects

The approach to analysis for detonation effects to sea turtles is described in Section 3.8.3.2.2, under Detonation Effects, and is similarly applied for assessing impacts under Alternative 2.

Missions Conducted in 2016

As listed in Table 2.2-2, Long Range Strike WSEP missions proposed for 2016 under Alternative 2 would be the same as Alternative 1, consisting of one live JASSM and eight SDB-I munitions, with four SDB-I releases occurring simultaneously. All weapons would detonate upon impact with the water surface. This level of live weapon releases is much lower than what is proposed for follow-on years and is, therefore, analyzed separately. The resulting total number of sea turtles potentially affected under Alternative 2 is the same as for Alternative 1 and is listed in Table 3.8-12. The numbers represent total impacts for all detonations combined. For some thresholds, exposure calculations from the model output resulted in decimal values, suggesting that a fraction of an animal was exposed. In these cases, the model results were rounded to the nearest whole number. Abundance, distribution, and density information was not sufficient to estimate exposures by species; numbers presented in the table are for all five species combined.

Acoustic modeling results indicate the potential for a total of one TTS exposure for sea turtles. It is likely that this exposure would be associated with either a green or hawksbill sea turtle. There would be no impacts to sea turtles associated with mortality, injury, permanent hearing effects, or behavioral effects. Exposure calculations do not take into account the mitigation measures described in Chapter 5, which may reduce the potential for effects.

Missions Conducted from 2017 to 2021

As shown in Table 2.2-2, Long Range Strike WSEP missions proposed for 2017–-2021 under Alternative 2 would consist of up to 6 live JASSM, 30 SDB-I, 30 SDB-II, 10 HARM, and 30 JDAM munitions per year. Under Alternative 2, all weapons, including JDAMs, would detonate at the water surface. The resulting total number of sea turtles potentially impacted under the various metrics is listed in Table 3.8-16. Abundance, distribution, and density information was not sufficient to estimate exposures by species; numbers presented in the table are for all five species combined. The numbers represent total impacts for all detonations combined per year and do not take into consideration the implementation of mitigation measures described in Chapter 5. Results are generally comparable to Alternative 1, with the same number of PTS exposures and slightly fewer TTS exposures.

Table 3.8-16. Annual Number of Sea Turtles Potentially Affected by Long Range Strike WSEP Missions Proposed for 2017-2021 Under Alternative 2

Species	Mortality	Slight Lung Injury	Slight GI Tract Injury	PTS	TTS	Behavioral
Sea turtle species	0	0	0	1	11	0

WSEP = Weapon Systems Evaluation Program

3.8.3.3.3 Comparison of Detonation Effects to Biological Resources Under Alternative 1 (Preferred Alternative) and Alternative 2

Eliminating all subsurface detonations would decrease impacts to marine mammals, sea turtles, and marine fish (including federally managed species) resulting from pressure and sound produced during explosions. The shock wave and acoustic signature associated with surface detonations are of lower intensity compared with underwater detonations. Therefore, it is expected that the potential for mortality, injury, and behavioral effects would be lessened. The decrease in impacts on fish is not quantified due to the variability in fish distribution at any given time in the open ocean. However, the decrease in the number of marine mammals and sea turtles potentially exposed to various pressure and noise thresholds annually, as determined by acoustic modeling for 2017–2021 missions, is summarized in Table 3.8-17 and Table 3.8-18.

Table 3.8-17. Marine Mammals Potentially Affected Under Alternative 1 (Preferred Alternative) and Alternative 2

Taxon	Total Number of Marine Mammal Exposures[1]							
	Mortality		Level A Harassment		Level B Harassment		Level B Harassment (Behavioral)	
	Alternative 1	Alternative 2	Alternative 1	Alternative 2	Alternative 1	Alternative 2	Alternative 1	Alternative 2
Mysticetes	0	0	0	0	0	0	5	5
Odontocetes	0	0	30	12	552	534	327	106
Hawaiian monk seal	0	0	0	0	0	0	1	0

1. Number of animals impacted by higher thresholds subtracted from less impactive thresholds

Table 3.8-18. Sea Turtles Potentially Affected Under Alternative 1 (Preferred Alternative) and Alternative 2

Total Number of Sea Turtle Exposures (all species)[1]											
Mortality		Slight Lung Injury		Slight GI Tract Injury		PTS		TTS		Behavioral	
Alt 1	Alt 2	Alt 1	Alt 2	Alt 1	Alt 2	Alt 1	Alt 2	Alt 1	Alt 2	Alt 1	Alt 2
0	0	0	0	0	0	1	1	15	11	0	0

1. Number of animals impacted by higher thresholds subtracted from less impactive thresholds

3.8.3.4 Conclusions

In summary, the conclusions on significance reached for Alternative 1 would be applicable to Alternative 2. There would be no significant impacts to biological resources resulting from Long Range Strike WSEP missions under Alternative 2.

This page is intentionally blank.

4.0 CUMULATIVE IMPACTS

This chapter addresses other considerations required by NEPA, including cumulative impacts; irreversible and irretrievable commitment of resources; environmental justice impacts; and protection of children from environmental health risks. The nature of the Proposed Action and lack of any action on shore does not warrant a discussion of climate change.

CEQ regulations implementing the procedural provisions of NEPA define cumulative impacts as: "The impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or nonfederal) or person undertakes such other actions" (40 CFR § 1508.7).

In order to analyze cumulative impacts, a cumulative impacts region must be identified for which impacts of the Proposed Action and other past, present, and reasonably foreseeable actions would be cumulatively recorded or experienced. The PMRF is the world's largest military test range capable of supporting subsurface, surface, air, and space operations, and as such is the site of ongoing military operations such as training, tactics development, and evaluation of air, surface, and subsurface weapons systems for the Navy, other DoD agencies, foreign military forces, and private industry. In addition to military activities, there are ongoing commercial and recreational activities within the offshore portion of the PMRF range, including commercial and recreational fishing and vessel traffic, whale watching, and scientific research. These activities have been described and analyzed in the Navy's *Hawaii Southern California Training and Testing Environmental Impact Statement/Overseas Environmental Impact Statement* (HSTT EIS/OEIS) (DoN, 2013). A review of the activities identified in the HSTT EIS/OEIS was conducted and is considered the basis of this cumulative impact analysis.

Due to the location the lack of land-based activities in the Proposed Action, and temporary nature of Air Force missions analyzed in this document, the relevant cumulative impacts region for this analysis is the airspace used and the offshore areas of the BSURE underwater tracking range.

4.1 Cumulative Impacts by Resource Area

4.1.1 Air Quality

Activities affecting air quality in the region include mobile sources such as maritime vessels and aircraft. Implementation of the Proposed Action would result in increases in air emissions within the ROI. Depending on the timing of onshore projects and other offshore testing and training operations, incremental increases in air emissions would result from aircraft, vessels, and other federal, municipal, and private activities. Federal ozone standards have not been exceeded in Hawaii during the past decade, despite the cumulative emissions from highway traffic, commercial and military aircraft operations, commercial and industrial facility operations, agriculture operations, and construction projects in both urban and rural areas. Aircraft and weapon detonations 40 to 50 miles offshore that occur in the open ocean area have limited effect on air quality due to their distance offshore and regional meteorological conditions. Minor increases in air emissions may occur as a result of implementation of the Proposed Action. However, emissions from several simultaneous projects are not likely to result in temporary or long-term combined emissions that would exceed General Conformity significance criteria or negatively affect attainment status. Further, the increase in aircraft and ordnance emissions associated with training would be minimal and not likely to adversely affect regional air quality.

None of the emissions generated by the proposed operations would exceed the *de minimis* or "conformity threshold" standards found in the Clean Air Act. The greenhouse gas (GHG) emissions from the Proposed Action do not represent "meaningful" GHG emissions.

No cumulative impacts for air quality are expected from the implementation of the Proposed Action.

4.1.2 Noise Impacts to the Public

Implementation of the Proposed Action would have no impacts to the public from noise because the impact point would be 44 NM out to sea and noise levels of 140 dBP or 115 dBP would not reach populated areas on land. Additionally, the safety hazard area, established for the protection of the public, including those participating in maritime transportation and commercial and recreational fishing, would prevent exposure to the public of noise levels at 140 dBP. As such, no additive or interactive effects with other noise sources would be anticipated. Therefore, no significant cumulative impacts due to noise associated with the offshore missions would occur.

4.1.3 Air Space

Implementation of the Proposed Action in conjunction with the cumulative actions in the HSTT EIS/OEIS (DoN, 2013) would not incrementally affect airspace within the ROI because no new special use airspace proposal, or any modification to the existing special use airspace, is contemplated to accommodate the Proposed Action. Under the Proposed Action, a limited number of aircraft from the CONUS would fly to PMRF airspace, conduct the missions, and fly back to the base it from which departed. No impacts to the ROI airways and jet routes are identified because of the required coordination with the Federal Aviation Administration (FAA).

PMRF would notify the FAA that a test is being planned that could temporarily affect airspace. The FAA would review the request and advise regarding windows of opportunity for the testing in order to minimize or avoid effects. The proposed missions would be conducted clear of established oceanic air routes or areas of known surface or air activity and in compliance with DoD Directive 4540.1, Army Regulation 95-10, Army Regulation 385-62 (U.S. Department of the Army, 1988). Aircraft would still be notified by the issuance of NOTAM to advise avoidance of the tracking radar area during program activities. The required range safety approval and range safety operational plans would be followed. The planned activity of no more than 2 missions per day over a five-day mission set (maximum of 10 missions annually) is not considered a significant level to cause environmental concern for the airspace. Consultation with the FAA on all matters affecting airspace would eliminate the possibility of indirect adverse impacts; therefore, no cumulative impacts are expected from the implementation of the Proposed Action.

4.1.4 Public Safety

Implementation of the Proposed Action in conjunction with the cumulative actions analyzed in the 2013 HSTT EIS/OEIS would not affect public health and safety within the ROI. The major factors influencing this analysis are: (1) the distance of hazardous operations from the islands; (2) the dispersed context of the hazardous operations, such that the intensity of the effects is not additive; (3) comprehensive Navy safety procedures in place to ensure that members of the general public are not placed in physical jeopardy due to testing; (4) specific range clearance procedures and practices implemented daily prior to commencement of hazardous operations; and (5) UXO would come to rest in waters deeper than 6,000 feet and at a point approximately 44 NM from land. Safety measures implemented for Alternative 1 have been in place and effective for several years without incident (DoN, 2010). Based on these factors, no significant cumulative impacts would occur relative to public health and safety.

4.1.5 Socioeconomics

The Proposed Action would occur within the boundaries of the PMRF; no change in personnel levels would occur; no impacts to schools, children, or minority populations would occur. No permanent population centers, low-income communities, or minority communities exist with the Proposed Action. Therefore, no communities would be disproportionately susceptible to adverse socioeconomic or environmental impacts. Any benefits to the local community associated with personnel on TDY would be minor and temporary due to the number of personnel and the length of the assignment. The potential exists to restrict access to the marine environment and temporarily disrupt commercial and recreational fishing, tourism, boating, and other offshore recreational use within the area of the safety footprint during training exercises. However, these restrictions would be brief and are not located in an area that would cumulatively affect socioeconomics. NOTMARs and NOTAMs would allow commercial and recreational fisherman and ocean boat industries to plan accordingly and mitigate costly delays or cancellations. Through continued implementation of advance communication and coordination management practices, the potential for significant cumulative impacts to socioeconomic resources are anticipated to be minimal.

4.1.6 Cultural Resources

Damage to the nature, integrity, and spatial context of cultural resources can have a cumulative impact if the initial act is compounded by other similar losses or impacts. The alteration or damage to underwater resources or the disturbance of shipwrecks may incrementally impact the maritime resources around the long range strike WSEP Operational Evaluations mission area.

Due to the depth of the seafloor at the target location in conjunction with the lack of identified resources, the likelihood of direct impacts to seafloor resources is considered remote. In conjunction with other similar past, present and future actions, these proposed mission activities are not expected to contribute to cumulative impacts to historic properties within the WSEP mission area.

4.1.7 Physical Resources

Chemicals introduced to the water column would be quickly dispersed by waves, currents, and tidal action and eventually be distributed throughout the surrounding open ocean waters. Explosive material that is not consumed in a detonation could sink to the substrate and bind to sediments. The quantity of such materials is expected to be inconsequential. Debris would not appreciably affect the sediments of the seafloor. Implementation of the Proposed Action in conjunction with the other relevant actions would not result in significant impacts to water quality within the ROI. The Proposed Action and alternatives involve incidental expenditure of chemical materials and debris into the water column and onto the seafloor. However, chemical, physical, or biological changes to sediments or water quality would be below applicable standards, regulations, and guidelines and would be within existing conditions or designated uses. When evaluated individually or cumulatively, these projects have either no impact or only short-term impacts on water quality. Water quality impacts associated with implementation of the Proposed Action are minor, localized, and temporary in nature and would not reach a level of significance, even in conjunction with the impacts of the other actions considered in a regional context. There would be no significant cumulative impacts to physical resources due to live air-to-surface weapons testing and training.

4.1.8 Biological Resources

Cumulative impacts to biological resources could occur if the species or habitats impacted by the Proposed Action would also be affected by other military, industrial, commercial, or recreational uses of the study area. Activities considered to be of primary concern include U.S. Navy testing and training conducted in the HRC, which consist of sonar use, impulsive acoustic sources, and the introduction of debris and other materials into the water column and substrate, among others. These activities have been described and analyzed in the Navy's *Hawaii-Southern California Training and Testing Environmental Impact Statement/Overseas Environmental Impact Statement* (DoN, 2013). Potential cumulative effects to marine mammals, sea turtles, fish, and EFH due to Navy activities are similar to the effects described in Section 3.8.3, (Biological Resources) *Environmental Consequences*. Individuals of marine mammal, sea turtle, and fish species affected by the Proposed Action of this EA/OEA could be similarly impacted by Navy activities, with potential impacts including mortality, injury, hearing effects, and behavioral effects. Navy actions with the potential to affect protected marine species must undergo evaluation pursuant to the MMPA and/or ESA and, similar to this EA/OEA, NMFS typically requires monitoring and mitigation measures to reduce the potential for impacts. NMFS has concluded that Navy testing and training, although likely to affect large numbers of individuals, would result in negligible impacts to marine mammals under the MMPA. In addition, NMFS concluded that the Navy's actions may affect and are likely to adversely affect, but are not likely to jeopardize the continued existence, of marine mammal and sea turtle species protected under the ESA. Due to the comparatively small addition of weapon testing under WSEP missions, the Air Force does not anticipate significant additional, cumulative effects.

Protected fish species may be intentionally or unintentionally impacted during commercial and recreational fishing. However, regulatory limits on commercial and recreational fishing and targeting of specific species and seasons during commercial fishing decrease the potential for substantial impacts to any fish population. The required use of equipment such as turtle excluder devices and dolphin-safe tuna nets have decreased injury and mortality associated with some commercial fisheries. Cumulative impacts to biological resources resulting from commercial and recreational fishing would not be significant.

4.2 Irreversible or Irretrievable Commitment of Resources

Implementation of the Proposed Action would irretrievably commit the use of nonrenewable resources such as fuel and materials contained in expended items. The Proposed Action would inevitably require the use of some nonrenewable resources. However, the action is not expected to result in the destruction or degradation of environmental resources to the point that their use is appreciably limited presently or in the future.

5.0 MANAGEMENT PRACTICES

No special operating procedures or mitigations would be required to mitigate impacts to resource areas, except for biological resources. Management practices applicable to biological resources consist of mitigation measures required by the NMFS as a result of consultations under the ESA and MMPA that are designed to decrease the number and severity of impacts to marine mammal and sea turtle species resulting from surface and subsurface detonations. These measures consist primarily of pre-mission and post-mission visual surveys of the impact area. Surveys would be conducted by Navy or Air Force personnel from a helicopter or other aircraft. Live weapons would not be deployed if protected marine species are observed within a given distance of the impact area. A complete description of required mitigation measures is provided below. These measures are also provided in the associated Biological Assessment and request for an LOA (Appendix A).

Mitigation Measures for Protected Marine Species

Unlike standard operating procedures, which are established for reasons other than environmental benefit, mitigation measures are implemented for the sole purpose of reducing a specific potential environmental impact on a particular resource. The mitigation procedures proposed for Long Range Strike WSEP missions are, in general, routinely implemented for test events in the PMRF as a result of previous Navy environmental compliance documents, ESA biological opinions, MMPA incidental harassment authorizations or letters of authorization, or other formal or informal consultations with regulatory agencies. The Air Force has worked with PMRF personnel to ensure mitigation measures are adequate and meet NMFS' expectations based on requirements identified for past similar actions conducted near the PMRF and BSURE areas. The Air Force's overall approach to assessing potential mitigation measures is based on two principles: (1) mitigations will be effective at reducing potential impacts on the resource, and (2) mitigation is consistent with mission objectives, range procedures, and safety measures.

For missions involving air-to-surface deployment of weapons in the BSURE area, such as Long Range Strike WSEP missions, mitigation procedures consist of radar monitoring and visual aerial surveys of the impact area for the presence of protected species (marine mammals and sea turtles). During aerial observation, Navy test range personnel may survey the area from an S-61N helicopter or C-62 aircraft that is based at the PMRF land facility (typically when missions are located relatively close to shore). Alternatively, when missions are located farther offshore, surveys may be conducted from mission aircraft (typically fighter aircraft such as F-15E, F-16, or F-22) or a U.S. Coast Guard C-130 aircraft.

Protected species surveys typically begin within one hour of weapon release and as close to the impact time as feasible, given human safety requirements. Survey personnel must depart the human hazard zone before weapon release, in accordance with Navy safety standards. Personnel conduct aerial surveys within an area defined by an approximately 2-NM (3,704-meter) radius around the impact point, with surveys typically flown in a star pattern. This survey distance is consistent with requirements already in place for similar actions at PMRF and encompasses all marine mammal and sea turtle mortality, slight lung injury, and GI tract injury impact areas. The survey distance covers some, but not all, PTS and TTS impact areas, and does not cover behavioral impact areas. Given operational constraints, surveying larger areas would not be feasible.

Observers would consist of aircrew operating the C-26, S-61N, and C-130 aircraft from PMRF and the Coast Guard. These aircrew are trained and experienced at conducting aerial marine mammal surveys and have provided similar support for other missions at PMRF. Aerial surveys are typically conducted at an altitude of about 200 feet, but altitude may vary somewhat depending on sea state and atmospheric conditions. If adverse weather conditions preclude the ability for aircraft to safely operate, missions would either be delayed until the weather clears or cancelled for the day. For 2016 Long Range Strike WSEP missions, one day has been designated as a weather backup day. The C-26 and other aircraft would generally be operated at a slightly higher altitude than the helicopter. The observers will be provided with the GPS location of the impact area. Once the aircraft reaches the impact area, pre-mission surveys typically last 30 minutes, depending on the survey pattern. The fixed-wing aircraft are faster than the helicopter and, therefore, protected species may be more difficult to spot. However, to compensate for the difference in speed, the aircraft may fly the survey pattern multiple times.

If a protected species is observed in the impact area, weapon release would be delayed until one of the following conditions is met: 1) the animal is observed exiting the impact area, 2) the animal is thought to have exited the impact area based on its course and speed, or 3) the impact area has been clear of any additional sightings for a period of 30 minutes. All weapons will be tracked and their water entry points will be documented. Post-mission surveys would begin immediately after the mission is complete and the Range Safety Officer declares the human safety area is reopened. Approximate transit time from the perimeter of the human safety area to the weapon impact area would depend on the size of the human safety area and would vary between aircraft, but it is expected to be less than 30 minutes. Post-mission surveys would be conducted by the same aircraft and aircrew that conducted the pre-mission surveys and would follow the same patterns as pre-mission surveys but would focus on the area down current of the weapon impact area to determine if protected species were affected by the mission (observation of dead or injured animals). During post-mission surveys, if an animal is found to have been injured or otherwise adversely impacted, NMFS will be notified immediately. Additional consultation with NMFS may be required prior to conducting the next mission.

NMFS has required the following mitigation measures based on MMPA and ESA consultations.

For marine mammals protected under the MMPA:

- If marine mammals are detected during pre-mission surveys, all activities shall be delayed until the marine mammals are determined to have left the area or 30 minutes have passed without redetection of the animal.

- Monitoring will be conducted as follows:

  - The 86 FWS will track its use of the PMRF BSURE area for Long Range Strike WSEP missions and marine mammal observations through the use of mission reporting forms.

  - Pre- and post-mission aerial surveys shall be conducted. Pre-mission surveys would begin approximately one hour prior to detonation. Post-detonation monitoring surveys will commence once the mission has ended and as soon as personnel declare the mission area safe.

  - The required monitoring area shall be approximately 2 NM (3,704 meters) from the target area radius around the impact point, with surveys flown in a star pattern. Aerial surveys shall be conducted at an altitude of approximately 200 feet. If adverse weather conditions preclude the ability for aircraft to safely operate, missions must either be delayed until the weather clears or cancelled for the day. The observers shall be provided with the GPS location of the impact area. Once the aircraft reaches the impact area, pre-mission surveys shall last for 30 minutes. The aircraft shall fly the survey pattern multiple times.

- Reporting will be conducted as follows:
  - The 86 FWS is required to submit a draft report on all monitoring conducted under the IHA within 90 days of the completion of marine mammal monitoring or 60 days prior to the issuance of any subsequent IHA for projects at PMRF, whichever comes first. A final report shall be prepared and submitted within 30 days following resolution of comments on the draft report from NMFS. This report must include:

        - Date and time of each Long Range Strike WSEP mission
        - A complete description of the pre-exercise and post-exercise activities related to mitigating and monitoring the effects of LRS WSEP missions on marine mammal populations
        - Results of the monitoring program, including numbers by species/stock of any marine mammals noted injured or killed as a result of the LRS WSEP mission and number of marine mammals (by species if possible) that may have been harassed due to presence within the zone of influence
    - The draft report will be subject to review and comment by NMFS. Any recommendations made by NMFS must be addressed in the final report prior to acceptance by NMFS. The draft report will be considered the final report for this activity under the IHA if NMFS has not provided comments and recommendations within 90 days of receipt of the draft report.
- Reporting injured or dead marine mammals will be conducted as follows:
    - In the unanticipated event that the specified activity clearly causes the take of a marine mammal in a manner prohibited by the IHA, such as an injury for species not authorized (Level A harassment), serious injury, or mortality, the 86 FWS shall immediately cease the specified activities and report the incident to the Office of Protected Resources, NMFS, 301-427-8496, and the Pacific Islands Regional Stranding Coordinator, NMFS, 808-354-2956. The report must include the following information:
        - Time and date of the incident
        - Description of the incident
        - Environmental conditions (e.g., wind speed and direction, Beaufort sea state, cloud cover, and visibility)
        - Description of all marine mammal observations in the 24 hours preceding the incident
        - Species identification or description of the animal(s) involved
        - Fate of the animal(s)
        - Photographs or video footage of the animal(s)
    - Activities shall not resume until NMFS is able to review the circumstances of the prohibited take. NMFS will work with the 86 FWS to determine what measures are necessary to minimize the likelihood of further prohibited take and ensure MMPA compliance. 86 FWS may not resume activities until notified by NMFS.
    - In the event that the 86 FWS discovers an injured or dead marine mammal, and the lead observer determines that the cause of the injury or death is unknown and the death is relatively recent (e.g., in less than a moderate state of decomposition), the 86 FWS shall immediately report the incident to the Office of Protected Resources, NMFS, and the Pacific Islands Regional Stranding Coordinator, NMFS. The report must include the same information identified above. Activities may continue while NMFS reviews the circumstances of the incident. NMFS will work with the 86 FWS to determine whether additional mitigation measures or modifications to the activities are appropriate.
    - In the event that the 86 FWS discovers an injured or dead marine mammal, and the lead observer determines that the injury or death is not associated with or related to the activities authorized in the IHA (e.g., previously wounded animal, carcass with moderate

to advanced decomposition, scavenger damage), the 86 FWS shall report the incident to the Office of Protected Resources, NMFS, and the Pacific Islands Regional Stranding Coordinator, NMFS, within 24 hours of the discovery. The 86 FWS shall provide photographs or video footage or other documentation of the stranded animal sighting to NMFS.

- Additional conditions include the following:
  - The 86 FWS must inform the Office of Protected Resources, NMFS (301-427-8496) prior to the initiation of any changes to the monitoring plan for a specified mission activity.
  - A copy of the IHA must be in the possession of the safety officer on duty when Long Range Strike WSEP missions are conducted
  - The IHA may be modified, suspended or withdrawn if the 86 FWS fails to abide by the conditions prescribed herein or if NMFS determines the authorized taking is having more than a negligible impact on the species or stock of affected marine mammals.

For marine mammals and sea turtles protected under the ESA:

- The Air Force must implement all mitigation and monitoring measures as described in the Biological Assessment.
- If a dead or injured marine mammal or sea turtle is observed during or following Long Range Strike WSEP activities, the Air Force shall immediately (within 24 hours of the discovery) contact NMFS and appropriate stranding networks.
- Within 120 days following completion mission activities, the Air Force shall submit a report to NMFS containing the following information:
  - Date and time of Long Range Strike WSEP missions
  - A complete description of the pre-mission and post-mission activities related to mitigating and monitoring the effects of Long Range Strike WSEP missions on marine mammals and sea turtles
  - Results of the protected species monitoring including numbers (by species if possible) of any marine mammals or sea turtles noted injured or killed as a result of Long Range Strike WSEP missions and the number of marine mammals or sea turtles (by species if possible) that may have been harassed due to presence within the zone of influence

6.0 PERSONS/AGENCIES CONTACTED

Mr. John Nakagawa Department of Business, Economic Development and Tourism Hawaii Office of Planning	Mr. Larry Foster Environmental Readiness Division, N465 U.S. Pacific Fleet Department of the Navy
Dr. Alan Downer, Ph.D. Hawaii State Historic Preservation Division	Mr. John Van Name Commander Pacific Fleet Environmental Department of the Navy
Ms. Laura McCue Permits and Conservation Division Office of Protected Resources National Marine Fisheries Service	Ms. Cory Scott Commander Pacific Fleet Environmental Department of the Navy
Ms. Jolie Harrison Permits and Conservation Division Office of Protected Resources National Marine Fisheries Service	CDR. Joan Malik Commander Pacific Fleet Environmental Department of the Navy
Ms. Caitlin Cameron ESA Interagency Coordination Division Office of Protected Resources National Marine Fisheries Service	Mr. John Burger PMRF Range Complex Sustainment Coordinator General Dynamics
Mr. Eric MacMillan ESA Interagency Coordination Division Office of Protected Resources National Marine Fisheries Service	Mr. Tim Ashby PMRF Range Complex Sustainment Coordinator SAIC
Ms. Cathryn Tortorici ESA Interagency Coordination Division Office of Protected Resources National Marine Fisheries Service	Mr. Errol Ceballos PMRF Operations Manager Department of the Navy
Ms. Danielle Jaywardene Habitat Conservation Division Pacific Islands Regional Office National Marine Fisheries Service	Mr. Edward Tam PMRF Range Safety Officer Department of the Navy
Mr. Gerry Davis Habitat Conservation Division Pacific Islands Regional Office National Marine Fisheries Service	Dr. Sean Hanser Marine Resources NAVFAC, Pacific Department of the Navy

This page is intentionally blank.

7.0 LIST OF PREPARERS

Amanda Robydek

Environmental Scientist
Project Manager
B.S., Environmental Science
Years of Experience: 10

Brad Boykin

Environmental Scientist
Air Quality
M.S., Biotechnology
B.S., Biomedical Science
Years of Experience: 12

Rick Combs

Environmental Scientist
Biological Resources
M.S., Biology
B.S., Biology
B.S., Business Administration
Years of Experience: 14

Stephanie Hiers

Environmental Scientist
Physical Resources
M.S., Conservation Ecology
B.S., Biology
Years of Experience: 19

Jason Koralewski

Environmental Scientist
Cultural Resources
M.A., Anthropology
B.A., Anthropology
Years of Experience: 20

Pamela McCarty

Environmental Scientist
Socioeconomics
M.S., Industrial and Systems Engineering
M.A., Applied Economics
B.S.B.A, Economics

Years of Experience: 9

Jamie McKee

Environmental Scientist
Noise, Public Safety
B.S., Marine Biology
Years of Experience: 30

8.0 REFERENCES

Acevedo-Gutiérrez, A., D. A. Croll, and B. R. Tershy, 2002. High feeding costs limit dive time in the largest whales. *Journal of Experimental Biology* 205: 1747-1753.

Afsal, V. V., P. P. Manojkumar, K. S. S. M. Yousuf, B. Anoop, and E. Vivekanandan, 2009. The first sighting of Longman's beaked whale, *Indopacetus pacificus*, in the southern Bay of Bengal. *Marine Biodiversity Records* 2: 1-3.

Aguayo, L. A., and T. R. Sanchez, 1987. Sighting records of Fraser's dolphin in the Mexican Pacific waters. *Scientific Reports of the Whales Research Institute* 38: 187-188.

Aguilar de Soto, N., M. P. Johnson, P. T. Madsen, F. Diaz, I. Dominguez, A. Brito, and P. Tyack, 2008. Cheetahs of the deep sea: Deep foraging sprints in short-finned pilot whales off Tenerife (Canary Islands). *Journal of Animal Ecology* 77(5): 936-947.

Aguilar, A., 2008. Fin whale *Balaenoptera physalus*. In *Encyclopedia of Marine Mammals*. W. F. Perrin, B. Wursig and J. G. M. Thewissen. Amsterdam, Academic Press: 433-437.

Aissi, M., A. Celona, G. Comparetto, R. Mangano, M. Wurtz, and A. Moulins, 2008. Large-scale seasonal distribution of fin whales (*Balaenoptera physalus*) in the central Mediterranean Sea. *Journal of the Marine Biological Association of the United Kingdom* 88: 1253-1261.

Aki, K., R. Brock, J. Miller, J. R. Mobley, Jr., P. J. Rappa, D. Tarnas, and M. Yuen, 1994. *A Site Characterization Study for the Hawaiian Islands Humpback Whale National Marine Sanctuary*. Prepared by University of Hawaii Sea Grant College Program School of Ocean and Earth Science and Technology. Prepared for NOAA.

Allen, B. M., and R. P. Angliss, 2010. *Alaska Marine Mammal Stock Assessments 2009*. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center. Seattle, Washington.

Allen, B. M., and R. P. Angliss, 2011. *Alaska Marine Mammal Stock Assessments 2010*. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center. NOAA Technical Memorandum NMFS-AFSC-223. May 2011. Seattle, Washington.

Allen, B. M., and R. P. Angliss, 2013. *Alaska Marine Mammal Stock Assessments 2012*. U.S. Department of Commerce, NOAA, NMFS, Alaska Fisheries Science Center. NOAA Technical Memorandum NMFS-AFSC-245.

Allen, B. M., and R. P. Angliss, 2015. *Alaska Marine Mammal Stock Assessments 2014*. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-AFSC-301. doi:10.7289/V5NS0RTS.

Alonso, M. K., S. N. Pedraza, A. C. M. Schiavini, R. N. P. Goodall, and E. A. Crespo, 1999. Stomach contents of false killer whales (*Pseudorca crassidens*) stranded on the coasts of the Strait of Magellan, Tierra del Fuego. *Marine Mammal Science* 15(3): 712-724.

Alves, F., A. Dinis, I. Cascao, and L. Freitas, 2010. Bryde's whale (*Balaenoptera brydei*) stable associations and dive profiles: New insights from foraging behavior. *Marine Mammal Science* 26(1): 202-212.

Anderson, R. C., R. Clark, P. T. Madsen, C. Johnson, J. Kiszka, and O. Breysse, 2006. Observations of Longman's beaked whale (*Indopacetus pacificus*) in the Western Indian Ocean. *Aquatic Mammals* 32(2): 223-231.

Antonelis, G. A., J. D. Baker, T. C. Johanos, R. C. Braun, and A. L. Harting, 2006. Hawaiian monk seal (*Monachus schauinslandi*: Status and conservation issues. *Atoll Research Bulletin* 543: 75-101.

Archer, F. I., and W. F. Perrin, 1999. *Stenella coeruleoalba*. *Mammalian Species* 603: 1-9.

Arenas, P., and M. Hall, 1992. The association of sea turtles and other pelagic fauna with floating objects in the eastern tropical Pacific Ocean. In M. Salmon and J. Wyneken (eds) *Proceedings of the Eleventh Annual Workshop on Sea Turtle Biology and Conservation*. NOAA Technical Memorandum NMFS-SEFSC-302, pp. 7-10. U.S. Department of Commerce, NOAA, NMFS.

Au, D. W. K., and W. L. Perryman, 1985. Dolphin habitats in the eastern tropical Pacific. *Fishery Bulletin* 83: 623-643.

Ayres, K. L., R. K. Booth, J. A. Hempelmann, K. L. Koski, C. K. Emmons, R. W. Baird, K. Balcomb-Bartok, M. B. Hanson, M. J. Ford, and S. K. Wasser, 2012. Distinguishing the impacts of inadequate prey and vessel traffic on an endangered killer whale (*Orcinus orca*) population. *PLoS ONE*: 7(6), pp 12.

Azzellino, A., S. Gaspari, S. Airoldi, and B. Nani, 2008. Habitat use and preferences of cetaceans along the continental slope and the adjacent pelagic waters in the western Ligurian Sea. *Deep Sea Research I* 55: 296–323.

Baird, R. W., 2005. Sightings of dwarf (*Kogia sima*) and pygmy (*K. breviceps*) sperm whales from the main Hawaiian Islands. *Pacific Science* 59: 461-466.

Baird, R. W., 2006. Hawaiʻi's other cetaceans. *Whale and Dolphin Magazine* 11: 28-31.

Baird, R. W., 2009a. A review of false killer whales in Hawaiian waters: Biology, status, and risk factors. *Cascadia Research Collective*: 41. Olympia, Washington.

Baird, R. W., 2009b. False killer whale *Pseudorca crassidens*. In *Encyclopedia of Marine Mammals* (Second Edition). W. F. Perrin, B. Wursig and J. G. M. Thewissen, Academic Press: 405-406.

Baird, R. W., A. M. Gorgone, D. L. Webster, D. J. McSweeney, J. W. Durban, A. D. Ligon, D. R. Salden, and M. H. Deakos, 2005a. *False Killer Whales Around the Main Hawaiian Islands: An Assessment of Interisland Movements and Population Size Using Individual Photo-Identification (*Pseudorca crassidens*)*. Report prepared under Order No. JJ133F04SE0120 from the Pacific Islands Fisheries Science Center, NMFS. Honolulu, Hawaii.

Baird, R. W., D. L. Webster, D. J. McSweeney, A. D. Ligon, and G. S. Schorr, 2005b. Diving Behavior and Ecology of Cuvier's (*Ziphius cavirostris*) and Blainville's Beaked Whales (*Mesoplodon densirostris*) in Hawaiʻi. La Jolla, California.

Baird, R. W., A. M. Gorgone, D. J. McSweeney, A. D. Ligon, M. H. Deakos, D. L. Webster, G. S. Schorr, K. K. Martien, D. R. Salden, and S. D. Mahaffy, 2009a. Population structure of island-associated dolphins: Evidence from photo-identification of common bottlenose dolphins (*Tursiops truncatus*) in the main Hawaiian Islands. *Marine Mammal Science* 25(2): 251-274.

Baird, R. W., D. J. McSweeney, G. S. Schorr, S. D. Mahaffy, D. L. Webster, J. Barlow, M. B. Hanson, J. P. Turner, and R. D. Andrews, 2009b. Studies of beaked whales in Hawaiʻi: Population size, movements, trophic ecology, social organization, and behaviour. In "Beaked Whale Research," S. J. Dolman, C. D. MacLeod and P. G. H. Evans, *European Cetacean Society*: 23-25.

Baird, R. W., A. D. Ligon, S. K. Hooker, and A. M. Gorgone, 2001. Subsurface and nighttime behaviour of pantropical spotted dolphins in Hawaiʻi. *Canadian Journal of Zoology*, 79(6), 988-996.

Baird, R. W., D. J. McSweeney, D. L. Webster, A. M. Gorgone, and A. D. Ligon, 2003a. *Studies of Odontocete Population Structure in Hawaiian Waters: Results of a Survey Through the Main Hawaiian Islands in May and June 2003*. NOAA. Seattle, Washington.

Baird, R. W., M. B. Hanson, E. E. Ashe, M. R. Heithaus, and G. J. Marshall, 2003b. *Studies of Foraging in "Southern Resident" Killer Whales During July 2002: Dive Depths, Bursts in Speed, and the Use of a "Crittercam" System for Examining Sub-Surface Behavior*. U.S. Department of Commerce, NMFS, National Marine Mammal Laboratory. Seattle, Washington.

Baird, R., D. McSweeney, C. Bane, J. Barlow, D. Salden, L. Antoine, R. LeDuc, and D. Webster, 2006a. Killer whales in Hawaiian waters: Information on population identity and feeding habits. *Pacific Science* 60(4): 523–530.

Baird, R. W., G. S. Schorr, D. L. Webster, D. J. McSweeney, and S. D. Mahaffy, 2006b. *Studies of Beaked Whale Diving Behavior and Odontocete Stock Structure in Hawai'i in March/April 2006.* NMFS. La Jolla, California.

Baird, R. W., D. L. Webster, S. D. Mahaffy, D. J. McSweeney, G. S. Schorr, and A. D. Ligon, 2008. Site fidelity and association patterns in a deep-water dolphin: Rough-toothed dolphins (*Steno bredanensis*) in the Hawaiian Archipelago. *Marine Mammal Science* 24(3): 535-553.

Baird, R. W., G. S. Schorr, D. L. Webster, D. J. McSweeney, M. B. Hanson, and R. D. Andrews, 2010a. Movements and habitat use of satellite-tagged false killer whales around the main Hawaiian Islands. *Endangered Species Research* 10: 107-121.

Baird, R., G. Schorr, D. Webster, D. McSweeney, M. Hanson, and R. Andrews, 2010b. Movements and habitat use of Cuvier's and Blainville's beaked whales in Hawaii: results from satellite tagging in 2009/2010. *C. Research*. La Jolla, California.

Baird, R. W., D. L. Webster, J. M. Aschettino, G. S. Schorr, and D. J. McSweeney, 2013. Odontocete cetaceans around the main Hawaiian Islands: Habitat use and relative abundance from small-boat sighting surveys. *Aquatic Mammals* 39:253-269.

Baird, R. W., D. L. Webster, G. S. Schorr, J. M. Aschettino, A. M. Gorgone, and S. D. Mahaffy, 2012. *Movements and Spatial Use of Odontocetes in the Western Main Hawaiian Islands: Results from Satellite-Tagging and Photo-Identification off Kauai and Niihau in July/August 2011*. Technical Report: NPS-OC-12-003CR; http://hdl.handle.net/10945/13855.

Baird, R. W., S. M. Jarvis, D. L. Webster, B. K. Rone, J. A. Shaffer, S. D. Mahaffy, A. M. Gorgone, and D. J. Moretti, 2014. *Odontocete Studies on the Pacific Missile Range Facility in July/August 2013: Satellite-Tagging, Photo Identification, and Passive Acoustic Monitoring.* U.S. Navy Pacific Fleet.

Baker, A. N., and B. Madon, 2007. Bryde's whales (*Balaenoptera* cf. *brydei* Olsen 1913) in the Hauraki Gulf and northeastern New Zealand waters. *Science for Conservation* 272: 4-14.

Baker, J. D., 2004. Evaluation of closed capture-recapture methods to estimate abundance of Hawaiian monk seals. *Ecological Applications* 14: 987-998.

Baker, J. D., 2008. Variation in the relationship between offspring size and survival provides insight into causes of mortality in Hawaiian monk seals. *Endangered Species Research* 5: 55-64.

Baker, J. D., A. L. Harting, and T. C. Johanos, 2006. Use of discovery curves to assess abundance of Hawaiian monk seals. *Marine Mammal Science* 22(4): 847-861.

Baker, J. D., and T. C. Johanos, 2004. Abundance of the Hawaiian monk seal in the main Hawaiian Islands. *Biological Conservation* 116(1): 103-110.

Balazs, G. H., 1980. Synopsis of Biological Data on the Green Sea Turtle in the Hawaiian Islands. NOAATM-NMFS-SWFC-7, pp. 141. U.S. Department of Commerce, NOAA, NMFS.

Balazs, G. H., 1995. Status of sea turtles in the central Pacific Ocean. In K. A. Bjorndal (ed), *Biology and Conservation of Sea Turtles* (revised ed., pp. 243-252). Smithsonian Institution Press: Washington, D.C.

Balazs, G., and M. Chaloupka, 2006. Recovery trend over 32 years at the Hawaiian green sea turtle rookery of French Frigate Shoals. *Atoll Research Bulletin* (543), 147-158.

Balazs, G. H., P. Craig, B. R. Winton, and R. K. Miya, 1994. Satellite telemetry of green sea turtles nesting at French Frigate Shoals, Hawaii, and Rose Atoll, American Samoa. In K. A. Bjorndal, A. B. Bolten, D. A. Johnson and P. J. Eliazar (eds), *Proceedings of the Fourteenth Annual Symposium on Sea Turtle Biology and Conservation*. NOAA Technical Memorandum NMFS-SEFSC-351, pp. 184-187. U.S. Department of Commerce, National Oceanic and Atmospheric Administration and NMFS.

Balcomb, K. C., 1987. *The Whales of Hawaii, Including All Species of Marine Mammals in Hawaiian and Adjacent Waters*. Marine Mammal Fund: San Francisco.

Baldwin, R. M., M. Gallagher, and K. Van Waerebeek, 1999. A review of cetaceans from waters off the Arabian Peninsula. In *The Natural History of Oman: A Festschrift for Michael Gallagher*. M. Fisher, S. A. Ghazanfur and J. A. Soalton, Backhuys Publishers: 161-189.

Barlow, J., 2003. *Cetacean Abundance in Hawaiian Waters During Summer/Fall 2002*. Southwest Fisheries Science Center, NMFS and NOAA. La Jolla, California.

Barlow, J., 2006. Cetacean abundance in Hawaiian waters estimated from a summer/fall survey in 2002. *Marine Mammal Science* 22(2): 446-464.

Barlow, J., J. Calambokidis, E. A. Falcone, C. S. Baker, A. M. Burdin, P. J. Clapham, J. K. B. Ford, C. M. Gabriele, R. LeDuc, D. K. Mattila, T. J. Quinn, L. Rojas-Bracho, J. M. Straley, B. L. Taylor, J. R. Urban, P. Wade, D. Weller, B. H. Witteveen, M. Yamaguchi, 2011. Humpback whale abundance in the North Pacific estimated by photographic capture-recapture with bias correction from simulation studies. *Marine Mammal Science*, 1-26.

Barlow, J., M. Ferguson, E. Becker, J. Redfern, K. Forney, I. Vilchis, P. Fiedler, T. Gerrodette, and L. Ballance, 2009. *Predictive Modeling of Cetacean Densities in the Eastern Pacific Ocean*. NOAA-TMNMFS-SWFSC-444, Southwest Fisheries Science Center, La Jolla, California.

Barlow, J., M. C. Ferguson, W. F. Perrin, L. Ballance, T. Gerrodette, G. Joyce, 2006. Abundance and densities of beaked and bottlenose whales (family Ziphiidae). *Journal of Cetacean Research and Management* 7(3): 263-270.

Barlow, J., and R. Gisiner, 2006. Mitigating, monitoring and assessing the effects of anthropogenic sound on beaked whales. *Journal of Cetacean Research and Management*, 7(3), 239-249.

Barlow, J., S. Rankin, A. Jackson, and A. Henry, 2008. Marine Mammal Data Collected During the Pacific Islands Cetacean and Ecosystem Assessment Survey (PICEAS) Conducted Aboard the NOAA Ship McArthur II, July–November 2005, NOAA: 27.

Barlow, J., S. Rankin, E. Zele, and J. Appler, 2004. *Marine Mammal Data Collected During the Hawaiian Islands Cetacean and Ecosystem Assessment Survey (HICEAS) Conducted Aboard the NOAA Ships McArthur and David Starr Jordan*. July–December 2002, NOAA: 32.

Barros, N. B., and A. A. Myrberg, 1987. Prey detection by means of passive listening in bottlenose dolphins (*Tursiops truncatus*). *Journal of the Acoustical Society of America* 82: S65.

Barros, N. B., and R. S. Wells, 1998. Prey and feeding patterns of resident bottlenose dolphins (*Tursiops truncatus*) in Sarasota Bay, Florida. *Journal of Mammalogy* 79(3): 1045-1059.

Bartol, S. M., and D. R. Ketten, 2006. Turtle and tuna hearing. In Y. Swimmer and R. W. Brill (eds), *Sea Turtle and Pelagic Fish Sensory Biology: Developing Techniques to Reduce Sea Turtle Bycatch in Longline Fisheries*. NOAA Technical Memorandum NMFS-PIFSC-7, pp. 98-103. U.S. Department of Commerce.

Bartol, S.M., J. A. Musick, M. L. Lenhardt, 1999. Auditory evoked potentials of the loggerhead sea turtle (*Caretta caretta*). *Copeia*: 836-840.

Baumgartner, M. F., 1997. The distribution of Risso's dolphin (*Grampus griseus*) with respect to the physiography of the northern Gulf of Mexico. *Marine Mammal Science* 13(4): 614-638.

Beatson, E., 2007. The diet of pygmy sperm whales, *Kogia breviceps*, stranded in New Zealand: Implications for conservation. *Reviews in Fish Biology and Fisheries* 17: 295-303.

Beavers, S. C., and E. R. Cassano, 1996. Movement and dive behavior of a male sea turtle (*Lepidochelys olivacea*) in the eastern tropical Pacific. *J. Herpetol*. 30(1):97-104.

Becker, E. A., K. A. Forney, D. G. Foley, J. Barlow, 2012. Density and spatial distribution patterns of cetaceans in the central North Pacific based on habitat models. U.S. Department of Commerce NOAA Technical Memorandum NMFS-SWFSC-490, 34 p.

Becker, N. M., 1995. *Fate of Selected High Explosives in the Environment: A Literature Review*. Los Alamos National Laboratory. LAUR-95-1018. March 1995.

Benoit-Bird, K. J., 2004. Prey caloric value and predator energy needs: Foraging predictions for wild spinner dolphins. *Marine Biology* 145: 435-444.

Benoit-Bird, K. J., and W. W. L. Au, 2003. Prey dynamics affect foraging by a pelagic predator (*Stenella longirostris*) over a range of spatial and temporal scales. *Behavioral Ecology and Sociobiology* 53: 364-373.

Benoit-Bird, K. J., W. W. Au, R. E. Brainard, and M. O. Lammers, 2001. Diel horizontal migration of the Hawaiian mesopelagic boundary community observed acoustically. *Marine Ecology Progress Series* 217: 1-14.

Benson, S. R., K. A. Forney, J. T. Harvey, J. V. Carretta, and P. H. Dutton, 2007. Abundance, distribution, and habitat of leatherback turtles (*Dermochelys coriacea*) off California, 1990-2003. *Fishery Bulletin*, 105(3), 337-347.

Bernard, H. J., and S. B. Reilly, 1999. Pilot Whales, *Globicephala* Lesson, 1828. In *Handbook of Marine Mammals*. S. H. Ridgway and R. Harrison. Academic Press. 6: 245-280. San Diego, California.

Berzin, A. A., and V. L. Vladimirov, 1981. Changes in abundance of whalebone whales in the Pacific and Antarctic since the cessation of their exploitation. *Reports of the International Whaling Commission* 31: 495-499.

Best, P. B., 1996. Evidence of migration by Bryde's whales from the offshore population in the southeast Atlantic. *Reports of the International Whaling Commission* 46: 315-322.

Best, P. B., D. S. Butterworth, and L. H. Rickett, 1984. An assessment cruise for the South African inshore stock of Bryde's whales (*Balaenoptera edeni*). *Reports of the International Whaling Commission* 34: 403-423.

Best, P. B., and C. H. Lockyer, 2002. Reproduction, growth and migrations of sei whales *Balaenoptera borealis* off the west coast of South Africa in the 1960s. *South African Journal of Marine Science* 24: 111-133.

Best, P. B., R. A. Rademeyer, C. Burton, D. Ljungblad, K. Sekiguchi, H. Shimada, D. Thiele, D. Reeb, and D. S. Butterworth, 2003. The abundance of blue whales on the Madagascar Plateau, December 1996. *Journal of Cetacean Research and Management* 5(3): 253-260.

Bjorndal, K. A., 1995. The consequences of herbivory for the life history pattern of the green sea turtle, *Chelonia mydas*. In K. A. Bjorndal (ed), *Biology and Conservation of Sea Turtles* (revised edition, pp. 111-116). Smithsonian Institution Press: Washington, D.C.

Bjorndal, K. A., 1997. Foraging ecology and nutrition of sea turtles. In P. L. Lutz and J. A. Musick (eds), *The Biology of Sea Turtles* (pp. 199-231). CRC Press: Boca Raton, Florida.

Bjorndal, K. A., 2003. Roles of loggerhead sea turtles in marine ecosystems. In A. B. Bolten and B. E. Witherington (eds), *Loggerhead Sea Turtles* (pp. 235-254). Smithsonian Institution Press: Washington, D.C.

Bjorndal, K. A., and A. B. Bolten, 1988. Growth rates of immature green sea turtles, *Chelonia mydas*, on feeding grounds in the southern Bahamas. *Copeia*, 1988(3), 555-564.

Bloodworth, B., and D. K. Odell, 2008. *Kogia breviceps*. *Mammalian Species* 819: 1-12.

Blumenthal, J. M., T. J. Austin, J. B. Bothwell, A. C. Broderick, G. Ebanks-Petrie, J. R. Olynik, B. J. Godley, 2009. Diving behavior and movements of juvenile hawksbill turtles *Eretmochelys imbricata* on a Caribbean coral reef. *Coral Reefs*, 28(1), 55-65. doi: 10.1007/s00338-008-0416-1.

Boggs, C. H., E. M. Oleson, K. A. Forney, B. Hanson, D. R. Kobayashi, B. L. Taylor, G. M. Ylitalo, 2010. *Status Review of Hawaiian Insular False Killer Whales (*Pseudorca crassidens*) under the Endangered Species Act*. NOAA Technical Memorandum NMFS-PIFSC-22, pp. 140 + appendices. U. S. Department of Commerce and NOAA.

Bolle, L. J., C.A.F. de Jong, S. M. Bierman, P. J. G. van Beek, and O.A. van Keken, 2012. Common sole larvae survive high levels of pile-driving sound in controlled exposure experiments. *PLoS ONE* 7(3): e33052. doi:10.1371/journal.pone.0033052.

Bolten, A. B., 2003. Variation in sea turtle life history patterns: Neritic vs. oceanic developmental stages. In P. L. Lutz, J. A. Musick, and J. Wyneken (eds), *The Biology of Sea Turtles* (Vol. II, pp. 243-258). CRC Press Boca Raton, Florida.

Bowen, B. W., F. A. Abreu-Grobois, G. H. Balazs, N. Kamezaki, C. J. Limpus, and R. J. Ferl, 1995. Trans-Pacific migrations of the loggerhead turtle (*Caretta caretta*) demonstrated with mitochondrial DNA markers. Proceedings of the National Academy of Sciences of the United States of America, 92, 3731-3734.

Bowen, B. W., A. M. Clark, A. F. Abreu-Grobois, A. Chaves, H. A. Reichart, and R. J. Ferl, 1998. Global phylogeography of the ridley sea turtles (*Lepidochelys* spp.) as inferred from mitochondrial DNA sequences. *Genetica*, 101, 179-189.

Bowen, B. W., and S. A. Karl, 1997. Population genetics, phylogeography, and molecular evolution. In P. L. Lutz and J. A. Musick (eds), *The Biology of Sea Turtles* (pp. 29-50). CRC Press: Boca Raton, Florida.

Bradford, A. L., and E. Lyman, 2015. *Injury Determinations for Humpback Whales and Other Cetaceans Reported to NOAA Response Networks in the Hawaiian Islands During 2007 – 2012* (pp. 29): National Oceanographic and Atmospheric Administration Technical Memorandum.

Bradford, A. L., K. A. Forney, E. M. Oleson, and J. Barlow, 2013. Line-transect abundance estimates of cetaceans in the Hawaiian EEZ. PIFSC Working Paper WP-13-004.

Bradford, A. L., E. A. Oleson, R. W. Baird, C. H. Boggs, K. A. Forney, and N. C. Young, 2015. *Revised Stock Boundaries for False Killer Whales (Psuedorca crassidens) in Hawaiian Waters* (pp. 37). Pacific Islands Fisheries Science Center: Hololulu, HI.

Bradshaw, C. J. A., C. R. McMahon, and G. C. Hays, 2007. Behavioral inference of diving metabolic rate in free-ranging leatherback turtles. *Physiological and Biochemical Zoology* 80(2), 209-219.

Bresette, M., J. C. Gorham, and B. D. Peery, 1998. Site fidelity and size frequencies of juvenile green turtles (*Chelonia mydas*) utilizing near shore reefs in St. Lucie County, Florida. *Marine Turtle Newsletter*, 82, 5-7. Retrieved from http://www.seaturtle.org/mtn/archives/mtn82/mtn82p5.shtml.

Bresette, M., D. Singewald, and E. De Maye, 2006. Recruitment of post-pelagic green sea turtles (*Chelonia mydas*) to nearshore reefs on Florida's east coast. In M. Frick, A. Panagopoulou, A. F. Rees, and K. Williams (eds), *Book of Abstracts: Twenty-Sixth Annual Symposium on Sea Turtle Biology and Conservation* (abstract, pp. 288). International Sea Turtle Society: Athens, Greece.

Brill, R. W., G. H. Balazs, K. N. Holland, R. K. C. Chang, S. Sullivan, and J. C. George, 1995. Daily movements, habitat use, and submergence intervals of normal and tumor-bearing juvenile green sea turtles (*Chelonia mydas L.*) within a foraging area in the Hawaiian islands. *Journal of Experimental Marine Biology and Ecology*, 185(2), 203-218. doi: 10.1016/0022-0981(94)00146-5.

Brillinger, D. R., B. S. Stewart, and C. S. Littnan, 2006. A meandering hylje. In *Festschrift for Tarmo Pukkila on his 60th Birthday*. E. P. Liski, J. Isotalo, J. Niemelä, S. Puntanen, and G. P. H. Styan. Finland, Dept. of Mathematics, Statistics and Philosophy, University of Tampere: 79-92.

Brown, C. H., and W. M. Brown, 1995. Status of sea turtles in the Southeastern Pacific: Emphasis on Peru. In K. A. Bjorndal (ed), *Biology and Conservation of Sea Turtles* (revised edition, pp. 235-240). Smithsonian Institution Press: Washington D.C.

Brownell, R. L., Jr., K. Ralls, S. Baumann-Pickering, and M. M. Poole, 2009. Behavior of melon-headed whales, *Peponocephala electra*, near oceanic islands. *Marine Mammal Science* 25(3): 639-658.

Bull, J. C., P. D. Jepson, R. K. Ssuna, R. Deaville, C. R. Allchin, R. J. Law, and A. Fenton, 2006. The relationship between polychlorinated biphenyls in blubber and levels of nematode infestations in harbour porpoises, *Phocoena phocoena*. *Parasitology*, 132, 565-573. doi:10.1017/S003118200500942X.

Byles, R. A., 1988. *Behavior and Ecology of Sea Turtles from Chesapeake Bay, Virginia*. Doctoral dissertation. College of William and Mary, Williamsburg, Virginia. Retrieved from http://www.sefsc.noaa.gov/PDFdocs/Byles_dissertation_1988.pdf.

Caillouet, C. W., C. T. Fontaine, S. A. Manzella-Tirpak, and D. J. Shaver, 1995. Survival of head-started Kemp's ridley sea turtles (*Lepidochelys kempii*) released into the Gulf of Mexico or adjacent bays. *Chelonian Conservation and Biology* 1(4):285-292.

Calambokidis, J., 2009. *Symposium on the Results of the SPLASH Humpback Whale Study: Final Report and Recommendations*.

Calambokidis, J., E. A. Falcone, T. J. Quinn, A. M. Burdin, P. J. Clapham, J. K. B. Ford, C. M. Gabriele, R. LeDuc, D. Mattila, L. Rojas-Bracho, J. M. Straley, B. L. Taylor, J. R. Urban, D. Weller, B. H. Witteveen, M. Yamaguchi, A. Bendlin, D. Camacho, K. Flynn, A. Havron, J. Huggins, N. Maloney, J. Barlow, and P. R. Wade, 2008. *SPLASH: Structure of Populations, Levels of Abundance and Status of Humpback Whales in the North Pacific*. Final report for Contract AB133F-03-RP-00078 prepared by Cascadia Research for U.S. Department of Commerce.

Calambokidis, J., G. H. Steiger, J. M. Straley, S. Cerchio, D. R. Salden, J. R. Urban, J. K. Jacobsen, O. von Ziegesar, K. C. Balcomb, C. M. Gabriele, M. E. Dahlheim, S. Uchida, G. Ellis, Y. Miyamura, P. Ladron De Guevara, M. Yamaguchi, F. Sato, S. A. Mizroch, L. Schlender, K. Rasmussen, J. Barlow, and T. J. Quinn II, 2001. Movements and population structure of humpback whales in the North Pacific. *Marine Mammal Science* 17(4): 769-794.

Caldwell, D. K., and M. C. Caldwell, 1989. Pygmy sperm whale *Kogia breviceps* (de Blainville, 1838): Dwarf sperm whale *Kogia simus* Owen, 1866. In S. H. Ridgway and R. Harrison (eds), *Handbook of Marine Mammals*. San Diego, California, Academic Press. 4: 234-260.

Canadas, A., R. Sagarminaga, and S. Garcia-Tiscar, 2002. Cetacean distribution related with depth and slope in the Mediterranean waters off southern Spain. *Deep Sea Research I* 49: 2053-2073.

Canese, S., A. Cardinali, C. M. Forunta, M. Giusti, G. Lauriano, E. Salvati, and S. Greco, 2006. The first identified winter feeding ground of fin whales (*Balaenoperta physalus*) in the Mediterranean Sea. *Journal of the Marine Biological Association of the United Kingdom* 86(4): 903-907.

Carr, A., 1986. Rips, FADS, and little loggerheads. *BioScience*, 36(2), 92-100.

Carr, A., 1987. New perspectives on the pelagic stage of sea turtle development. *Conservation Biology*, 1(2), 103-121.

Carr, A., M. Carr, and A. B. Meylan, 1978. The ecology and migrations of sea turtles, 7. The west Carribean green sea turtle colony. *Bulletin of the American Museum of Natural History*, 162(1), 1-46.

Carr, A., and A. B. Meylan, 1980. Evidence of passive migration of green sea turtle hatchlings in Sargassum. *Copeia*, 1980(2), 366-368.

Carretta, J. V., K. A. Forney, M. S. Lowry, J. Barlow, J. Baker, D. Johnston, B. Hanson, R. L. Brownell, Jr., J. Robbins, D. Mattila, K. Ralls, M. M. Muto, D. Lynch, and L. Carswell, 2010. *U.S. Pacific Marine Mammal Stock Assessments: 2009*. La Jolla, California, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, NMFS, Southwest Fisheries Science Center: 336.

Carretta, J. V., K. A. Forney, E. Oleson, K. Martien, M. M. Muto, M. S. Lowry, J. Barlow, J. Baker, B. Hanson, D. Lynch, L. Carswell, R. L. Brownell, J. Robbins, D. K. Mattila, K. Ralls, and M. C. Hill, 2011. *U.S. Pacific Marine Mammal Stock Assessments: 2010*. La Jolla, California, U.S. Department of Commerce, NOAA, NMFS, Southwest Fisheries Science Center: 352.

Carretta, J. V., E. M. Oleson, D. W. Weller, A. R. Lang, K. A. Forney, J. Baker, M. M. Muto, B. Hanson, A. J. Orr, H. Huber, M. S. Lowry, J. Barlow, J. E. Moore, D. Lynch, L. Carswell, and R. L. Brownell, Jr., 2016. *U.S. Pacific Marine Mammal Stock Assessments: 2015*. U.S. Department of Commerce, NOAA Technical Memorandum, NOAA-TMNMFS-SWFSC-549. 414 p.

Carretta, J. V., T. Price, D. Petersen, and R. Read, 2005. Estimates of marine mammal, sea turtle, and seabird mortality in the California drift gillnet fishery for swordfish and thresher shark, 1996–2002. *Marine Fisheries Review* 66(2): 21-30.

Cascadia Research, 2010. Hawai‘i's False Killer Whales.

Cascadia Research, 2012a. An Update on Our June/July 2012 Kaua‘i Field Work. Cascadia Research Collective. http://www.cascadiaresearch.org/hawaii/july2011.htm.

Cascadia Research, 2012b. Beaked Whales in Hawai‘i. Cascadia Research Collective. http://www.cascadiaresearch.org/hawaii/beakedwhales.htm.

Cetacean and Turtle Assessment Program, 1982. *A Characterization of Marine Mammals and Turtles in the Mid- and North Atlantic Areas of the U.S. Outer Continental Shelf*. 540.

Chaloupka, M., P. Dutton, and H. Nakano, 2004. Status of sea turtle stocks in the Pacific. In *Papers Presented at the Expert Consultation on Interactions Between Sea Turtles and Fisheries Within an Ecosystem Context*. FAO

Fisheries Report No. 738, Supplement, pp. 135-164. Food and Agriculture Organization of the United Nations: Rome, Italy.

Chaloupka, M., N. Kamezaki, and C. Limpus, 2008a. Is climate change affecting the population dynamics of the endangered Pacific loggerhead sea turtle? *Journal of Experimental Marine Biology and Ecology*, 356(1-2), 136-143. doi: 10.1016/j.jembe.2007.12.009.

Chaloupka, M., T. M. Work, G. Balazs, S. K. Murakawa, and R. Morris, 2008b. Cause-specific temporal and spatial trends in green sea turtle strandings in the Hawaiian Archipelago (1982–2003). *Marine Biology*, 154, 887-898.

Chaloupka, M. Y., and J. A. Musick, 1997. Age, growth, and population dynamics. In P. L. Lutz and J. A. Musick (eds), *The Biology of Sea Turtles* (pp. 233-276). CRC Press: Boca Raton, Florida.

Chivers, S. J., R. W. Baird, K. M. Martien, B. L. Taylor, E. Archer, A. M. Gorgone, B. L. Hancock, N. M. Hedrick, D. Matilla, D. J. McSweeney, E. M. Oleson, C. L. Palmer, V. Pease, K. M. Robertson, J. Robbins, J. C. Salinas, G. Schorr, M. Schultz, J. L. Thieleking, and D. L. Webster, 2010. *Evidence of Genetic Differentiation for Hawaii Insular False Killer Whales (*Pseudorca crassidens*).* NOAA Technical Report NMFS NOAA-TM-NMFS-SWFSC-458: 49.

Chivers, S. J., R. W. Baird, D. J. McSweeney, D. L. Webster, N. M. Hedrick, and J. C. Salinas, 2007. Genetic variation and evidence for population structure in eastern North Pacific false killer whales (*Pseudorca crassidens*). *Canadian Journal of Zoology* 85: 783-794.

Chua, T. H., 1988. Nesting population and frequency of visits in *Dermochelys coriacea* in Malaysia. *Journal of Herpetology*, 22(2), 192-207.

Clapham, P. J., 2000. The humpback whale: seasonal feeding and breeding in a baleen whale. In J. Mann, R. C. Connor, P. L. Tyack and H. Whitehead (eds), *Cetacean Societies: Field Studies of Dolphins and Whales*, University of Chicago Press: 173-196.

Clapham, P. J., and D. K. Mattila, 1990. Humpback whale songs as indicators of migration routes. *Marine Mammal Science* 6(2): 155-160.

Clapham, P. J., and J. G. Mead, 1999. *Megaptera novaeangliae*. *Mammalian Species* 604: 1-9.

Clark, S. L., and J. W. Ward, 1943. The effects of rapid compression waves on animals submerged in water. *Surgery, Gynecology & Obstetrics* 77:403-412.

Clarke, M. R., 1996. Cephalopods as prey. III. Cetaceans." *Philosophical Transactions of the Royal Society of London* 351: 1053-1065.

Cliffton, K., D. O. Cornejo, and R. S. Felger, 1995. Sea turtles of the Pacific coast of Mexico. In K. A. Bjorndal (ed), *Biology and Conservation of Sea Turtles* (revised edition, pp. 199-209). Smithsonian Institution Press: Washington, D.C.

Commander, Navy Installations Command (CNIC), 2016a. Pacific Missile Range Facility Barking Sands: Navy Gateway Inns and Suites. Accessed online on January 1, 2016.

Commander, Navy Installations Command (CNIC), 2016b. Pacific Missile Range Facility Barking Sands: MWR Guest Pass Program. Accessed online on January 11, 2016.

Conant, T. A., P. H. Dutton, T. Eguchi, S. P. Epperly, C. C. Fahy, M. H. Godfrey, B. E. Witherington, 2009. *Loggerhead Sea Turtle (*Caretta caretta*) 2009 Status Review Under the U.S. Endangered Species Act*. pp. 222. Loggerhead Biological Review Team and NMFS.

Continental Shelf Associates (CSA), 2004. *Explosive Removal of Offshore Structures – Information Synthesis Report*. U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, Louisiana. OCS Study MMS 2003-070. 181 pp. + app.

Cox, T., T. Ragen, A. Read, E. Vox, R. Baird, K. Balcomb, L. Benner, 2006. Understanding the impacts of anthropogenic sound on beaked whales. *Journal of Cetacean Research and Management*, 7(3), 177-187.

Craig, A. S., and L. M. Herman, 2000. Habitat preferences of female humpback whales Megaptera novaeangliae in the Hawaiian Islands are associated with reproductive status. *Marine Ecology Progress Series* 193: 209-216.

Cummings, W. C., 1985. Bryde's whale *Balaenoptera edeni* (Anderson, 1878). In S. H. Ridgway and R. Harrison (eds), *Handbook of Marine Mammals*. 3: 137-154. Academic Press: San Diego, California.

Dahlheim, M. E., and J. E. Heyning, 1999. Killer whale *Orcinus orca* (Linnaeus, 1758). In S. H. Ridgway and R. Harrison (eds) *Handbook of Marine Mammals*. 6: 281-322. Academic Press: San Diego, California.

Dalebout, M. L., J. G. Mead, C. S. Baker, A. N. Baker, and A. L. van Helden, 2002. A new species of beaked whale *Mesoplodon perrini* sp. n. (Cetacea: Ziphiidae) discovered through phylogenetic analyses of mitochondrial DNA sequences. *Marine Mammal Science* 18(3): 577-608.

Dalebout, M. L., G. J. B. Ross, C. S. Baker, R. C. Anderson, P. B. Best, V. G. Cockcroft, H. L. Hinsz, V. M. Peddemors, and R. L. Pitman, 2003. Appearance, distribution and genetic distinctiveness of Longman's beaked whale, *Indopacetus pacificus*. *Marine Mammal Science* 19(3): 421-461.

Darrach, M. R., A. Chutjian, and G. A. Plett, 1998. Trace explosives signatures from World War II unexploded undersea ordnance. *Environmental Science Technology*, 1998, 32(9), pp 1354-1358. DOI: 10.1021/es970992h.

Davenport, J., 1988. Do diving leatherbacks pursue glowing jelly? *British Herpetological Society Bulletin*, 24, 20-21.

Davenport, J., and G. H. Balazs, 1991. "Fiery bodies" — Are pyrosomas an important component of the diet of leatherback turtles? *British Herpetological Society Bulletin*, 37, 33-38.

Davis, R. W., W. E. Evans, and B. Wursig, 2000. *Cetaceans, Sea Turtles and Seabirds in the Northern Gulf of Mexico: Distribution, Abundance and Habitat Associations*. Volume II: Technical Report. New Orleans, Louisiana, U.S. Department of the Interior, Geological Survey, Biological Resources Division, and Minerals Management Service, Gulf of Mexico OCS Region: 346.

Davis, R. W., G. S. Fargion, N. May, T. D. Leming, M. Baumgartner, W. E. Evans, L. J. Hansen, and K. Mullin, 1998. Physical habitat of cetaceans along the continental slope in the north-central and western Gulf of Mexico. *Marine Mammal Science* 14(3): 490-507.

Davis, R. W., N. Jaquet, D. Gendron, U. Markaida, G. Bazzino, and W. Gilly, 2007. Diving behavior of sperm whales in relation to behavior of a major prey species, the jumbo squid, in the Gulf of California, Mexico. *Marine Ecology Progress Series* 333: 291-302.

Debusschere, Elisabeth, Kris Hostens, Dominique Adriaens, Bart Ampe, Dick Botteldooren, Gadrun De Boeck, Amelie De Muynck, Amit Kumar Sinha, Sofie Vandendriessche, Luc Van Hoorebeke, Magda Vincx, and Steven Degraer, 2015. Acoustic stress responses in juvenile sea bass *Dicentrarchus labrax* induced by offshore pile driving. *Environmental Pollution* 208 (2016) 747-757.

Department of Defense (DoD), 2015. *Area Planning: Special Use Airspace Pacific-Australasia Antarctica*. DoD Information Publication. 10 December 2015.

Department of Defense Noise Working Group, 2013. *An Overview of Blast Noise: Characteristics, Assessment and Mitigation.* Washington, D.C. December.

Department of Land and Natural Resources (DLNR), 2014. *Adoption of Chapter 13-60.9 Hawaii Administrative Rules*.

Department of the Navy (DoN), 1998. *Final Environmental Impact Statement, Shock-Testing the SEAWOLF Submarine*. Washington, D.C.

Department of the Navy (DoN), 2001. *Integrated Natural Resources Management Plan: Pacific Missile Range Facility Hawaii.* Final Report. pp. 376. Prepared by Belt Collins Hawaii Ltd. Prepared for Commander, Navy Region Hawaii. Honolulu, Hawaii.

Department of the Navy (DoN), 2002. *Environmental Assessment for the Hawaiian Islands Shallow Water Training Range.* Final Report. Prepared by Commander in Chief U.S. Pacific Fleet. Pearl Harbor, Hawaii.

Department of the Navy (DoN), 2006. *Rim of the Pacific Exercise After Action Report: Analysis of Effectiveness of Mitigation and Monitoring Measures as Required Under the Marine Mammals Protection Act (MMPA) Incidental Harassment Authorization and the National Defense Exemption from the Requirements of the MMPA for Mid-Frequency Active Sonar Mitigation Measures*.

Department of the Navy (DoN), 2008. *Barking Sands Underwater Range Expansion (BSURE) Refurbishmen,. Final Record of Categorical Exclusion/Overseas Environmental Assessment*. March 2008.

Department of the Navy (DoN), 2009. *Marine Species Monitoring for the U.S. Navy's Hawaii Range Complex and the Southern California Range Complex, 2009 Annual Report*. Available at www.nmfs.noaa.gov/pr/permits /incidental.htm#applications.

Department of the Navy (DoN), 2010. *Environmental Assessment/Overseas Environmental Assessment for the Pacific Missile Range Facility Intercept Test Support*. Kauai, Hawaii. April.

Department of the Navy (DoN), 2011. *Marine Species Monitoring for the U.S. Navy's Hawaii Range Complex and the Southern California Range Complex, 2011 Annual Report*. Available at www.nmfs.noaa.gov/pr/permits/ incidental.htm#applications.

Department of the Navy (DoN), 2013. *Hawaii-Southern California Training and Testing Final Environmental Impact Statement/Overseas Impact Statement (EIS/OEIS)*. August 2013.

Department of the Navy (DoN), 2014. *Commander Task Force 3rd and 7th Fleet Navy Marine Species Density Database. NAVFAC Pacific Technical Report*. Naval Facilities Engineering Command Pacific, Pearl Harbor, HI.

Department of the Navy (DoN), 2015a. *Hawaii-Southern California Training and Testing (HSTT)–2014 Annual Monitoring Report*. U.S. Navy Pacific Fleet: Pearl Harbor, HI.

Department of the Navy (DoN), 2015b. Section 3.4 Marine Mammals *in Northwest Training and Testing Environmental Impact Statement/Overseas Environmental Impact Statement, Final.* U.S. Pacific Fleet: Pearl Harbor, HI.

DeRuiter, S. L., and K. L. Doukara, 2012. Loggerhead turtles dive in response to airgun sound exposure. *Endangered Species Research*, 16(1), 55–63. doi: 10.3354/esr00396.

Dobbs, K. A., J. D. Miller, C. J. Limpus, and A. M. Landry, Jr., 1999. Hawksbill turtle, *Eretmochelys imbricata*, nesting at Milman Island, northern Great Barrier Reef, Australia. *Chelonian Conservation and Biology*, 3(2), 344-361.

Dodd, C. K., Jr., 1988. *Synopsis of the Biological Data on the Loggerhead Sea Turtle* Caretta caretta *(Linnaeus 1758).* Biological Report 88(14), pp. 110. Washington, D.C.: USFWS.

Dolar, M. L. L., 2008. Fraser's dolphin *Lagenodelphis hosei*. In W. F. Perrin, B. Würsig and J. G. M. Thewissen (eds), *Encyclopedia of Marine Mammals*. San Diego, CA, Academic Press: 485-487.

Donahue, M. A., and W. L. Perryman, 2008. Pygmy killer whale *Feresa attenuata*. In W. F. Perrin, B. Würsig and J. G. M. Thewissen (eds) *Encyclopedia of Marine Mammals*. San Diego, CA, Academic Press: 938-939.

Donohue, M. J., and D. G. Foley, 2007. Remote sensing reveals links among the endangered Hawaiian monk seal, marine debris and El Niño. *Marine Mammal Science* 23(2): 468–473.

Donovan, G. P., 1991. A review of IWC stock boundaries. *Reports of the International Whaling Commission Special Issue* 13: 39-68.

Dunphy-Daly, M. M., M. R. Heithaus, and D. E. Claridge, 2008. Temporal variation in dwarf sperm whale (*Kogia sima*) habitat use and group size off Great Abaco Island, Bahamas. *Marine Mammal Science* 24(1): 171-182.

Dutton, P. H. (unpublished data, 5 February). Sea turtle satellite data inquiry. K. Kelly, Tetra Tech, Inc, Honolulu, HI.

Dutton, P., 2006. Building our knowledge of the leatherback stock structure. *SWoT Report - State of the World's Sea Turtles*, I, 10-11. Retrieved from http://seaturtlestatus.org/report/swot-volume-1.

Dutton, P. H., G. H. Balazs, and A. E. Dizon, 1998. Genetic stock identification of sea turtles caught in the Hawaii-based pelagic longline fishery. In S. P. Epperly and J. Braun (eds.), *Proceedings of the Seventeenth Annual Sea Turtle Symposium* [Abstract]. NOAA Technical Memorandum NMFS-SEFSC-415, pp. 45-46. U. S. Department of Commerce, NOAA, NMFS. Available from http://www.nmfs.noaa.gov/pr/species/ turtles/symposia.htm.

Dutton, P. H., B. W. Bowen, D. W. Owens, A. Barragan, and S. K. Davis, 1999. Global phylogeography of the leatherback turtle (*Dermochelys coriacea*). *Journal of Zoology*, London, 248, 397-409.

D'Vincent, C. G., R. M. Nilson, and R. E. Hanna, 1985. Vocalization and coordinated feeding behavior of the humpback whale in southeastern Alaska. *Scientific Reports of the Whales Research Institute* 36: 41-47.

Eckert, K. L, 1987. Environmental unpredictability and leatherback sea turtle (*Dermochelys coriacea*) nest loss. *Herpetologica*, 43(3), 315-323.

Eckert, K. L., 1993. *The Biology and Population Status of Marine Turtles in the North Pacific Ocean*. NOAA-TM-NMFS-SWFSC-186, pp. 166. U.S. Department of Commerce, NOAA, NMFS.

Eckert, K. L., 1995. Anthropogenic threats to sea turtles. In K. A. Bjorndal (ed), *Biology and Conservation of Sea Turtles* (revised ed., pp. 611-612). Washington, D.C.: Smithsonian Institution Press.

Eckert, K. L., K. A. Bjorndal, F. A. Abreu-Grobois, and M. Donnelly (eds), 1999. *Research and Management Techniques for the Conservation of Sea Turtles*. IUCN/SSC Marine Turtle Specialist Group Publication No. 4, pp. 24.

Eckert, K. L., and S. A. Eckert, 1988. Pre-reproductive movements of leatherback sea turtles (*Dermochelys coriacea*) nesting in the Caribbean. *Copeia*, 1988(2), 400-406.

Eckert, S. A., 2002. Distribution of juvenile leatherback sea turtle *Dermochelys coriacea* sightings. *Marine Ecology Progress Series*, 230, 289-293.

Eckert, S. A., H. C. Liew, K. L. Eckert, and E. H. Chan, 1996. Shallow water diving by leatherback turtles in the South China Sea. *Chelonian Conservation and Biology*, 2(2), 237-243.

Eckert, S. A., D. W. Nellis, K. L. Eckert, and G. L. Kooyman, 1986. Diving patterns of two leatherback sea turtles (*Dermochelys coriacea*) during internesting intervals at Sandy Point, St. Croix, U.S. Virgin Islands. *Herpetologica*, 42(3), 381-388.

Eckert, S. A., K. L. Eckert, P. Ponganis, and G. L. Kooyman, 1989a. Diving and foraging behavior of leatherback sea turtles (*Dermochelys coriacea*). Canadian Journal of Zoology, 67, 2834-2840.

Eckert, K. L., S. A. Eckert, T. W. Adams, and A. D. Tucker, 1989b. Inter-nesting migrations by leatherback sea turtles (*Dermochelys coriacea*) in the West Indies. *Herpetologica*, 45(2), 190-194.

Eckert, S. A., and L. Sarti-Martinez, 1997. Distant fisheries implicated in the loss of the world's largest leatherback nesting population. *Marine Turtle Newsletter*, 78, 2-7. Retrieved from http://www.seaturtle.org/mtn/archives/mtn78/mtn78p2.shtml.

Eisenberg, J. F., and J. Frazier, 1983. A leatherback turtle (*Dermochelys coriacea*) feeding in the wild. *Journal of Herpetology*, 17(1), 81-82.

Erbe, C., A. MacGillivray, and R. Williams, 2012. Mapping cumulative noise from shipping to inform marine spatial planning. *Journal of the Acoustical Society of America*, 132(5): 423-428.

Ersts, P. J., and H. C. Rosenbaum, 2003. Habitat preference reflects social organization of humpback whales (*Megaptera novaeangliae*) on a wintering ground. *Journal of Zoology*, London 260: 337-345.

Fair, P. A., J. Adams, G. Mitchum, T. C. Hulsey, J. S. Reif, M. Houde, G. D. Bossart, 2010. Contaminant blubber burdens in Atlantic bottlenose dolphins (*Tursiops truncatus*) from two southeastern US estuarine areas: Concentrations and patterns of PCBs, pesticides, PBDEs, PFCs, and PAHs. *Science of the Total Environment*, 408, 1577-1597. doi:10.1016/j.scitotenv.2009.12.021.

Falcone, E., G. Schorr, A. Douglas, J. Calambokidis, E. Henderson, M. McKenna, J. Hildebrand, and D. Moretti, 2009. Sighting characteristics and photo-identification of Cuvier's beaked whales (*Ziphius cavirostris*) near San Clemente Island, California: A key area for beaked whales and the military? *Marine Biology* 156: 2631-2640.

Fauquier, D. A., M. J. Kinsel, M. D. Dailey, G. E. Sutton, M. K. Stolen, R. S. Wells, and F. M. D. Gulland, 2009. Prevalence and pathology of lungworm infection in bottlenose dolphins *Tursiops truncatus* from southwest Florida. *Diseases of Aquatic Organisms*, 88, 85-90. doi: 10.3354/dao02095.

Ferguson, M. C., 2005. *Cetacean Population Density in the Eastern Pacific Ocean: Analyzing Patterns With Predictive Spatial Models*. Doctoral dissertation. University of California, San Diego.

Ferguson, M. C., J. Barlow, T. Gerrodette, and P. Fiedler, 2001. Meso-scale patterns in the density and distribution of ziphiid whales in the eastern Pacific Ocean. *Fourteenth Biennial Conference on the Biology of Marine Mammals*. Vancouver, British Columbia.

Ferguson, M. C., J. Barlow, S. B. Reilly, and T. Gerrodette, 2006. Predicting Cuvier's (*Ziphius cavirostris*) and Mesoplodon beaked whale population density from habitat characteristics in the eastern tropical Pacific Ocean. *Journal of Cetacean Research and Management* 7(3): 287-299.

Fertl, D., A. Acevedo-Gutierrez, and F. L. Darby, 1996. A report of killer whales (*Orcinus orca*) feeding on a carcharhinid shark in Costa Rica. *Marine Mammal Science*, 12(4):606-611. October 1996.

Finneran, J. J., D. A. Carder, C. E. Schlundt, and S. H. Ridgway, 2005. Temporary threshold shift in bottlenose dolphins (*Tursiops truncatus*) exposed to mid-frequency tones. *Journal of the Acoustical Society of America* 118:2696-2705.

Finneran J. J., C. E. Schlundt, D. A. Carder, J. A. Clark, J. A. Young, J. B. Gaspin, and S. H. Ridgway, 2000. Auditory and behavioral responses of bottlenose dolphins (*Tursiops truncatus*) and a beluga whale (*Delphinapterus leucas*) to impulsive sounds resembling distant signatures of underwater explosions. *Journal of the Acoustical Society of America* 108:417-431.

Finneran, J. J., and A. K. Jenkins, 2012. *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis*. U.S. Navy, SPAWAR Systems Center. April.

Finneran, J. J., and C. E. Schlundt, 2004. *Effects of Intense Pure Tones on the Behavior of Trained Odontocetes*. Technical Report (Vol. TR 1913). San Diego, California: SSC San Diego.

Finneran J. J., C. E. Schlundt, R. Dear, D. A. Carder, S. H. Ridgway, 2002. Temporary shift in masked hearing thresholds in odontocetes after exposure to single underwater impulses from a seismic watergun. *Journal of the Acoustical Society of America* 111:2929-2940.

Ford, J. K. B., 2008. Killer whale *Orcinus orca*. In W. F. Perrin, B. Würsig, and J. G. M. Thewissen (eds), *Encyclopedia of Marine Mammals*. San Diego, California, Academic Press: 650-657.

Ford, J. K. B., G. M. Ellis, D. R. Matkin, K. C. Balcomb, D. Briggs, and A. B. Morton, 2005. Killer whale attacks on minke whales: Prey capture and antipredator tactics. *Marine Mammal Science* 21(4):603-618.

Ford, J. K. B., G. M. Ellis, P. F. Olesiuk, and K. C. Balcomb, 2009. Linking killer whale survival and prey abundance: food limitation in the oceans' apex predator. *Biol. Lett*.

Forestell, P. H., and J. Urbán-Ramirez, 2007. Movement of a humpback whale (*Megaptera novaeangliae*) between the Revillagigedo and Hawaiian Archipelagos within a winter breeding season. *LAJAM* 6(1): 97-102.

Forney, K., R. Baird, and E. Oleson, 2010. *Rationale for the 2010 Revision of Stock Boundaries for the Hawai'i Insular and Pelagic Stocks of False Killer Whales*, Pseudorca crassidens. NOAA Technical Memorandum, NOAA-TM-NMFS-SWFSC-471.

Fossette, S., S. Ferraroli, H. Tanaka, Y. Ropert-Coudert, N. Arai, K. Sato, and J. Georges, 2007. Dispersal and dive patterns in gravid leatherback turtles during the nesting season in French Guiana. *Marine Ecology Progress Series* 338, 233-247.

Frair, W., R. G. Ackman, and N. Mrosovsky, 1972. Body temperature of *Dermochelys coriacea*: Warm turtle from cold water. *Science*, 177, 791-793.

Frantzis, A., J. C. Goold, E. K. Skarsoulis, M. I. Taroudakis, and V. Kandia, 2002. Clicks from Cuvier's beaked whales, *Ziphius cavirostris* (L). *Journal of the Acoustical Society of America* 112(1): 34-37.

Frazier, J. G., 2001. General natural history of marine turtles. In K. L. Eckert and F. A. Abreu-Grobois (eds), *Proceedings of the Marine Turtle Conservation in the Wider Caribbean Region: A Dialogue for Effective Regional Management*. pp. 3-17. WIDECAST, IUCN-MTSG, WWF and UNEP-CEP.

Fretey, J., 2001. *Biogeography and Conservation of Marine Turtles of the Atlantic Coast of Africa*. CMS Technical Series Publication, no. 6, pp. 429. Bonn, Germany: UNEP/CMS Secretariat.

Fritts, T. H., 1981. Pelagic feeding habits of turtles in the eastern Pacific. *Marine Turtle Newsletter*, 17(1), 4-5. Retrieved from http://www.seaturtle.org/mtn/archives/mtn17/mtn17p4.shtml.

Fritts, T. H., M. L. Stinson, and R. M. Márquez, 1982. Status of sea turtle nesting in southern Baja California, México. *Bulletin of the Southern California Academy of Sciences*, 81(2), 51-60.

Fulling, G. L., K. D. Mullin, and C. W. Hubard, 2003. Abundance and distribution of cetaceans in outer continental shelf waters of the U.S. Gulf of Mexico. *Fishery Bulletin* 101: 923-932.

Fulling, G. L., P. H. Thorson, and J. Rivers, 2011. Distribution and abundance estimates for cetaceans in the waters off Guam and the Commonwealth of the Northern Mariana Islands. *Pacific Science*, 1-46. University of Hawai‘i Press.

Gallo-Reynoso, J. P., and A. L. Figueroa-Carranza, 1995. Occurrence of bottlenose whales in the waters of Isla Guadalupe, Mexico. *Marine Mammal Science* 11(4): 573-575.

Gannier, A., 2000. Distribution of cetaceans off the Society Islands (French Polynesia) as obtained from dedicated surveys. *Aquatic Mammals* 26(2): 111-126.

Gannier, A., and E. Praca, 2007. SST fronts and the summer sperm whale distribution in the north-west Mediterranean Sea. *Journal of the Marine Biological Association of the United Kingdom* 87: 187-193.

Gannier, A., and K. L. West, 2005. Distribution of the rough-toothed dolphin (*Steno bredanensis*) around the Windward Islands (French Polynesia). *Pacific Science* 59: 17-24.

Geijer, C. K. A., and A. J. Read, 2013. Mitigation of marine mammal bycatch in U.S. fisheries since 1994. *Biological Conservation* 159:54-60.

Gilman, E., 2008. *Pacific Leatherback Conservation and Research Activities, Financing and Priorities*. pp. 31. Honolulu, Hawaii: The World Conservation Union and Western Pacific Fishery Management Council and IUCN.

Gilman, E., S. Clarke, N. Brothers, J. Alfaro-Shigueto, J. Mandelman, J. Mangel, and T. Werner, 2007. *Shark Depredation and Unwanted Bycatch in Pelagic Longline Fisheries: Industry Practices and Attitudes, and Shark Avoidance Strategies*. pp. 164. Honolulu, Hawaii: Western Pacific Regional Fishery Management Council.

Gilmartin, W. G., and J. Forcada, 2009. Monk seals *Monachus monachus, M. tropicalis*, and *M. schauinslandi*. In W. F. Perrin, B. Wursig and J. G. M. Thewissen (eds), *Encyclopedia of Marine Mammals*. Academic Press: 741-744.

Glickman, T., 2015. Personal communication via electronic mail from Mr. Timothy Glickman, Civ PACAF/A3/6TA, to Greg Kesler, Leidos. Subject: W-188 Stratification. 17 December 2015.

Godley, B. J., A. C. Broderick, F. Glen, and G. C. Hays, 2003. Post-nesting movements and submergence patterns of loggerhead marine turtles in the Mediterranean assessed by satellite tracking. *Journal of Experimental Marine Biology and Ecology*, 287, 119-134.

Godley, B. J., D. R. Thompson, S. Waldron, and R. W. Furness, 1998. The trophic status of marine turtles as determined by stable isotope analysis. *Marine Ecology Progress Series*, 166, 277-284.

Goertner, J. F., 1982. *Prediction of Underwater Explosion Safe Ranges for Sea Mammals*. Dahlgren, Virginia, Naval Surface Weapons Center: 25.

Goff, G. P., and G. B. Stenson, 1988. Brown adipose tissue in leatherback sea turtles: A thermogenic organ in an endothermic reptile? *Copeia*, 1988(4), 1071-1075.

Goldbogen, J. A., J. Calambokidis, R. E. Shadwick, E. M. Oleson, M. A. McDonald, and J. A. Hildebrand, 2006. Kinematics of foraging dives and lunge-feeding in fin whales. *Journal of Experimental Biology* 209: 1231-1244.

Grant, G. S., and D. Ferrell, 1993. Leatherback turtle, *Dermochelys coriacea* (Reptilia: Dermochelidae): Notes on near-shore feeding behavior and association with cobia. *Brimleyana*, 19, 77-81.

Greaves F. C., R. H. Draeger, O. A. Brines, J. S. Shaver, and E. L. Corey, 1943. An experimental study of concussion. *United States Naval Medical Bulletin* 41:339-352.

Green, G. A., J. J. Brueggeman, R. A. Grotefendt, C. E. Bowlby, M. L. Bonnell, and K. C. Balcomb III, 1992. *Cetacean Distribution and Abundance off Oregon and Washington, 1989-1990*. Los Angeles, California, Minerals Management Service: 100.

Greer, A. E., Jr., J. D. Lazell, Jr., and R. M. Wright, 1973. Anatomical evidence for a counter-current heat exchanger in the leatherback turtle (*Dermochelys coriacea*). *Nature*, 244, 181.

Gregr, E. J., and A. W. Trites, 2001. Predictions of critical habitat for five whale species in the waters of coastal British Columbia. *Canadian Journal of Fisheries and Aquatic Sciences* 58: 1265-1285.

Griffin, R. B., and N. J. Griffin, 2004. Temporal variation in Atlantic spotted dolphin (*Stenella frontalis*) and bottlenose dolphin (*Tursiops truncatus*) densities on the west Florida continental shelf. *Aquatic Mammals* 30(3): 380-390.

Hailman, J. P., and A. M. Elowson, 1992. Ethogram of the nesting female loggerhead (*Caretta caretta*). *Herpetologica*, 48(1), 1-30.

Hamer, D. J., S. J. Childerhouse, and N. J. Gales, 2010. Mitigating operational interactions between odontocetes and the longline fishing industry: A preliminary global review of the problem and of potential solutions. *International Whaling Commission*: 30. Tasmania, Australia.

Hanabusa, Colleen, 2014. PMRF: More than missile defense. *The Garden Island*. February 6, 2014.

Handley, C. O., 1966. A synopsis of the genus Kogia (pygmy sperm whales). In K. S. Norris (ed), *Whales, Dolphins, and Porpoises*. University of California Press: 62-69.

Hatase, H., Y. Matsuzawa, W. Sakamoto, N. Baba, and I. Miyawaki, 2002. Pelagic habitat use of an adult Japanese male loggerhead turtle *Caretta caretta* examined by the Argos satellite system. *Fisheries Science*, 68, 945-947.

Hatase, H., K. Omuta, and K. Tsukamoto, 2007. Bottom or midwater: alternative foraging behaviours in adult female loggerhead sea turtles. *Journal of Zoology*, 273(1), 46-55. doi: 10.1111/j.1469-7998.2007.00298.x.

Hatase, H., K. Sato, M. Yamaguchi, K. Takahashi, and K. Tsukamoto, 2006. Individual variation in feeding habitat use by adult female green sea turtles (*Chelonia mydas*): Are they obligately neritic herbivores? *Oecologia*, 149(1), 52-64. doi: 10.1007/s00442-006-0431-2.

Hawaii History.org, 2016. Library of Hawaiian History. Accessed at http://www.hawaiihistory.org/index.cfm?fuseaction=ig.page&CategoryID=294 on January 27.

Hawaii Department of Transportation (HI DOT) 2016. A Guide to Port Hawaii. Accessed online at http://hidot.hawaii.gov/harbors/files/2012/10/A-Guide-To-Port-Hawaii.pdf.

Hawaii State Historic Preservation Division, 2012. *Programmatic Agreement Among the Commander Navy Region Hawaii, the Advisory Council on Historic Preservation, and the Hawaii State Historic Preservation Officer Regarding Navy Undertakings in Hawaii*.

Hawaii Tourism Authority, 2014. *2014 Annual Visitor Research Report*.

Hawaiian Islands Humpback Whale National Marine Sanctuary, 2014. Resource Protection: Entanglement Responses, Outcomes, and Summaries. Accessed online at http://hawaiihumpbackwhale.noaa.gov/res/rescue_reports.html. Last revised on 8 May 2014.

Hawkes, L. A., A. C. Broderick, M. S. Coyne, M. H. Godfrey, L.-F. Lopez-Jurado, P. Lopez-Suarez, and B. J. Godley, 2006. Phenotypically linked dichotomy in sea turtle foraging requires multiple conservation approaches. *Current Biology*, 16, 990-995.

Hays, G. C., J. D. R. Houghton, C. Isaacs, R. S. King, C. Lloyd, and P. Lovell, 2004. First records of oceanic dive profiles for leatherback turtles, *Dermochelys coriacea*, indicate behavioural plasticity associated with long-distance migration. *Animal Behaviour*, 67, 733-743.

Hays, G. C., J. D. Metcalfe, and A. W. Walne, 2004. The implications of lung-regulated buoyancy control for dive depth and duration. *Ecology*, 85(4), 1137-1145.

Hazel, J., I. R. Lawler, H. Marsh, and S. Robson, 2007. Vessel speed increases collision risk for the green sea turtle *Chelonia mydas*. *Endangered Species Research*, 3(2), 105-113. doi: 10.3354/esr003105.

HDR, 2012. *Summary Report: Compilation of Visual Survey Effort and Sightings for Marine Species Monitoring in the Hawaii Range Complex, 2005-2012*. Prepared for Commander, U.S. Pacific Fleet, Pearl Harbor, Hawaii. Submitted to Naval Facilities Engineering Command Pacific, San Diego, California.

Heithaus, M. R., J. J. McLash, A. Frid, L. M. Dill, and G. Marshall, 2002. Novel insights into green sea turtle behaviour using animal-borne video cameras. *Journal of the Marine Biological Association of the United Kingdom*, 82(6), 1049-1050.

Herman, L. M., C. S. Baker, P. H. Forestell, and R. C. Antinoja, 1980. Right whale *Balaena glacialis* sightings near Hawaii: A clue to the wintering grounds? *Marine Ecology Progress Series*, 2, 271-275.

Hewitt, A. D., T. F. Jenkins, T. A. Ranney, J. A. Stark, M. E. Walsh, S. Taylor, M. R. Walsh, D. J. Lambert, N. M. Perron, N. H. Collins, and R. Karn, 2003. *Estimates for Explosives Residue from the Detonation of Army Munitions*. U.S. Army Corps of Engineers ERDC/CRREL TR-03-16. September 2003.

Heyning, J. E., 1989. Cuvier's beaked whale *Ziphius cavirostris*, G. Cuvier, 1823. In S. H. Ridgway and R. Harrison (eds), *Handbook of Marine Mammals*. San Diego, California, Academic Press. 4: 289-308.

Heyning, J. E., and J. G. Mead, 2008. Cuvier's beaked whale *Ziphius cavirostris*. In W. F. Perrin, B. Wursig, and J. G. M. Thewissen (eds), *Encyclopedia of Marine Mammals*. Academic Press: 294-295.

Hickmott, L. S., 2005. Diving behaviour and foraging behaviour and foraging ecology of Blainville's and Cuvier's beaked whales in the Northern Bahamas. Master of Research in Environmental Biology, master's thesis, University of St. Andrews.

Hildebrand, J. A., 2009. Anthropogenic and natural sources of ambient noise in the ocean. *Marine Ecology Progress Series*, vol. 395: 5-20.

Hill, M. C., A. L. Bradford, K. R. Andrews, R. W. Baird, M. H. Deakos, S. D. Johnston, D. W. Mahaffy, A. J. Milette, E. M. Oleson, J. Östman-Lind, A. A. Pack, S. H. Rickards, and S. Yin, 2011. Abundance and movements of spinner dolphins off the Main Hawaiian Islands. Pacific Islands Fisheries Science Center Working Paper WP-11-013.

Hirth, H. F., 1997. Synopsis of the Biological Data on the Green Sea Turtle *Chelonia mydas* (Linnaeus 1758). Biological Report 97(1). Washington, D.C.: USFWS.

Hirth, H., J. Kasu, and T. Mala, 1993. Observations on a leatherback turtle *Dermochelys coriacea* nesting population near Piguwa, Papua New Guinea. *Biological Conservation*, 65, 77-82.

Hirth, H. F., and L. H. Ogren, 1987. *Some Aspects of the Ecology of the Leatherback Turtle* Dermochelys coriacea *at Laguna Jalova, Costa Rica*. NOAA Technical Report NMFS 56, pp. 14, U.S. Department of Commerce, NOAA, NMFS.

Hoelzel, A. R., E. M. Dorsey, and S. J. Stern, 1989. The foraging specializations of individual minke whales. *Animal Behavior* 38:786-794.

Hoelzel A. R, J. Hey, M. E. Dahlheim, C. Nicholson, V. Burkanov, N. Black, 2007. Evolution of population structure in a highly social top predator, the killer whale. *Molecular Biology and Evolution*, 24, 1407–1415.

Hoffsommer, J. C., D. J. Glover, and J. M. Rosen, 1972. *Analysis of Explosives in Sea Water and in Ocean Floor Sediment and Fauna*. Naval Ordnance Laboratory, White Oak, Silver Spring, Maryland. NOTLR 72-215. September 1972.

Horwood, J., 1987. *The Sei Whale: Population Biology, Ecology, and Management*. New York, New York, Croom Helm: 375.

Horwood, J., 2009. Sei whale *Balaenoptera borealis*. In W. F. Perrin, B. Wursig and J. G. M. Thewissen (eds), *Encyclopedia of Marine Mammals*. San Diego, California, Academic Press: 1001-1003.

Houser, D. S., J. J. Finneran, and S. H. Ridgway, 2010. Research with Navy marine mammals benefits animal care, conservation and biology. *International Journal of Comparative Psychology*, 23, 249-268.

Hughes, G. R., P. Luschi, R. Mencacci, and F. Papi, 1998. The 7000-km oceanic journey of a leatherback turtle tracked by satellite. *Journal of Experimental Marine Biology and Ecology*, 229, 209-217.

Hui, C. A., 1985. Undersea topography and the comparative distribution of two pelagic cetaceans. *Fishery Bulletin* 83: 472-475.

Intergovernmental Panel on Climate Change, 1995. *IPCC Second Assessment: Climate Change 1995*.

James, M. C., and T. B. Herman, 2001. Feeding of *Dermochelys coriacea* on medusae in the northwest Atlantic. *Chelonian Conservation and Biology*, 4(1), 202-205.

James, M. C., and N. Mrosovsky, 2004. Body temperatures of leatherback turtles (*Dermochelys coriacea*) in temperate waters off Nova Scotia, Canada. *Canadian Journal of Zoology*, 82, 1302-1306. doi: 10.1139/Z04-110.

James, M. C., R. A. Myers, and C. A. Ottensmeyer, 2005. Behaviour of leatherback sea turtles, *Dermochelys coriacea*, during the migratory cycle. *Proceedings of the Royal Society B: Biological Sciences*, 272, 1547-1555. doi: 10.1098/rspb.2005.3110.

James, M. C., S. A. Sherrill-Mix, K. Martin, and R. A. Myers, 2006. Canadian waters provide critical foraging habitat for leatherback sea turtles. *Biological Conservation*, 133(3), 347-357.

Jefferson, T. A., 2009. Rough-toothed dolphin *Steno bredanensis*. In W. F. Perrin, B. Wursig and J. G. M. Thewissen (eds), *Encyclopedia of Marine Mammals* (Second Edition) (pp. 990-992): Academic Press.

Jefferson, T. A., and N. B. Barros, 1997. *Peponocephala electra*. *Mammalian Species* 553: 1-6.

Jefferson, T. A., and S. Leatherwood, 1994. *Lagenodelphis hosei*. *Mammalian Species* 470: 1-5.

Jefferson, T. A., M. A. Webber, et al., 2008. *Marine Mammals of the World: A Comprehensive Guide to Their Identification*. London, UK, Elsevier: 573 p.

Jefferson, T. A., M. A. Webber, and R. L. Pitman, 2015. *Marine Mammals of the World: A Comprehensive Guide to Their Identification* (2nd ed.). Academic Press.

Jepson, P., P. Bennett, R. Deaville, C. R. Allchin, J. Baker, and R. Law, 2005. Relationships between polychlorinated biphenyls and health status in harbor porpoises (*Phocoena phocoena*) stranded in the United Kingdom. *Environmental Toxicology and Chemistry*, 24(1), 238-248.

Jones, T. T., 2009. Energetics of the leatherback turtle (*Dermochelys coriacea*). Thesis.

Jonsen, I. D., R. A. Myers, and M. C. James, 2007. Identifying leatherback turtle foraging behaviour from satellite telemetry using a switching state-space model. *Marine Ecology Progress Series* 337, 255-264.

Kalb, H., and D. Owens, 1994. Differences between solitary and arribada nesting olive ridley females during the internesting period. In K. A. Bjorndal, A. B. Bolten, D. A. Johnson, and P. J. Eliazar (eds), *Proceedings of the Fourteenth Annual Symposium on Sea Turtle Biology and Conservation*. NOAA Technical Memorandum NMFS-SEFSC-351, pp. 68. U.S. Department of Commerce, NOAA, NMFS.

Kamezaki, N., Y. Matsuzawa, O. Abe, H. Asakawa, T. Fujii, K. Goto, I. Wakabayashi, 2003. Loggerhead turtles nesting in Japan. In A. B. Bolten and B. E. Witherington (eds), *Loggerhead Sea Turtles* (pp. 210-217). Washington D.C.: Smithsonian Books.

Kanda, N., M. Goto, H. Kato, M. V. McPhee, and L. A. Pastene, 2007. Population genetic structure of Bryde's whales (*Balaenoptera brydei*) at the inter-oceanic and trans-equatorial levels. *Conservative Genetics* 8(4): 853-864.

Kato, H., and W. F. Perrin, 2008. Bryde's whales *Balaenoptera edeni/brydei*. In W. F. Perrin, B. Wursig and J. G. M. Thewissen (eds), *Encyclopedia of Marine Mammals*. San Diego, California, Academic Press: 158-163.

Katsumata, E., K. Ohishi, and T. Maruyama, 2004. Rehabilitation of a rescued pygmy sperm whale stranded on the Pacific coast of Japan. *IEEE Journal*: 488-491.

Keck, N., O. Kwiatek, F. Dhermain, F. Dupraz, H. Boulet, C. Danes, C. Laprie, A. Perrin, J. Godenir, L. Micout, and G. Libeau, 2010. Resurgence of Morbillivirus infection in Mediterranean dolphins off the French coast. *The Veterinary Record* 166(21): 654-655.

Keevin, T. M., and G. L. Hempen, 1997. *The Environmental Effects of Underwater Explosions with Methods to Mitigate Impacts*. U.S. Army Corps of Engineers, St. Louis District.

Keinath, J. A., and J. A. Musick, 1993. Movements and diving behavior of a leatherback turtle, *Dermochelys coriacea*. *Copeia*, 1993(4), 1010-1017.

Kemp, N. J., 1996. Habitat loss and degradation. In *The Conservation of Whales and Dolphins*. M. P. Simmonds and J. Lagerquist, B. A., B. R. Mate, J. G. Ortega-Ortiz, M. Winsor, and J. Urban-Ramirez, 2008. Migratory movements and surfacing rates of humpback whales (*Megaptera novaeangliae*) satellite tagged at Socorro Island, Mexico. *Marine Mammal Science*, 24(4): 815–830. D. Hutchinson. New York, NY, John Wiley & Sons: 476.

Kenney, R. D., and H. E. Winn, 1987. Cetacean biomass densities near submarine canyons compared to adjacent shelf/slope areas. *Continental Shelf Research* 7: 107-114.

Ketten, D. R., J. Lien, and S. Todd, 1993. Blast injury in humpback whale ears: Evidence and implications. *Journal of the Acoustical Society of America* 94(3), 1849–1850.

Kishiro, T., 1996. Movements of marked Bryde's whales in the western North Pacific. *Reports of the International Whaling Commission* 46: 421-428.

Kjeld, M., et al., 2006. Sex hormones and reproductive status of the North Atlantic fin whales (*Balaenoptera physalus*) during the feeding season. *Aquatic Mammals* 32(1): 75-84.

Koala Landing Resort and Spa, 2013. A Guide to Deep Sea Fishing Around Kauai. September 17, 2013. Accessed online at: http://koalalandingresort.com/a-guide-to-deep-sea-fishing-around-kauai/ on January 25, 2016.

Krahn, M. M., M. J. Ford, W. F. Perrin, P. R. Wade, R. P. Angliss, M. B. Hanson, B. L. Taylor, G. M. Ylitalo, M. E. Dahlheim, J. E. Stein, and R. S. Waples, 2004. *2004 Status Review of Southern Resident Killer Whales (*Orcinus orca*) Under the Endangered Species Act*. Seattle, WA, U.S. Department of Commerce, NOAA, NMFS, Northwest Fisheries Science Center: 73.

Kruse, S., D. K. Caldwell, and M. C. Caldwell, 1999. Risso's dolphin *Grampus griseus* (G. Cuvier, 1812). In S. H. Ridgway and R. Harrison (eds), *Handbook of Marine Mammals*. San Diego, CA, Academic Press. 6:183-212.

Kuker, K. J., J. A. Thomson, and U. Tscherter, 2005. Novel surface feeding tactics of minke whales, *Balaenoptera acutorostrata*, in the Saguenay-St. Lawrence National Marine Park. *Canadian Field-Naturalist* 119(2): 214-218.

Lagerquist, B. A., B. R. Mate, J. G. Ortega-Ortiz, M. Winsor, and J. Urban-Ramirez, 2008. Migratory movements and surfacing rates of humpback whales (*Megaptera novaeangliae*) satellite tagged at Socorro Island, Mexico. *Marine Mammal Science*, 24(4): 815–830.

Laist, D. W., 1997. Impacts of marine debris: Entanglement of marine life in marine debris including a comprehensive list of species with entanglement and ingestion records. In J. M. Coe and D. B. Rogers (eds), *Marine Debris: Sources, Impacts, and Solutions* (pp. 99-140). New York, NY: Springer-Verlag.

Lammers, M. O., 2004. Occurrence and behavior of Hawaiian spinner dolphins (*Stenella longirostris*) along Oahu's leeward and south shores. *Aquatic Mammals* 30(2): 237-250.

Lammers, M. O., P. I. Fisher-Pool, W. W. L. Au, C. G. Meyer, K. B. Wong, and R. E. Brainard, 2011. Humpback whale *Megaptera novaeangliae* song reveals wintering activity in the Northwestern Hawaiian Islands. *Marine Ecology Progress Series*, 423: 261–268.

Law, K. L., S. Moret-Ferguson, N. A. Maximenko, G. Proskurowski, E. E. Peacock, J. Hafner, and C. M. Reddy, 2010. Plastic accumulation in the North Atlantic subtropical gyre. *Science* 329, 1185 (2010). DOI: 10.1126/science.1192321.

Lazell, J. D., Jr., 1980. New England waters: Critical habitat for marine turtles. *Copeia*, 1980(2), 290-295.

Leatherwood, S., W. F. Perrin, V. L. Kirby, C. L. Hubbs, and M. Dahlheim, 1980. Distribution and movements of Risso's dolphin, *Grampus griseus*, in the eastern North Pacific. *Fishery Bulletin* 77(4): 951-963.

Lenhardt, M. L., 1994. Seismic and very low frequency sound induced behaviors in captive loggerhead marine turtles (*Caretta caretta*). In K. A. Bjorndal, et al. (eds), *Fourteenth Annual Symposium on Sea Turtle Biology and Conservation*, Hilton Head, South Carolina.

Lenhardt, M. L., 2002. Sea turtle auditory behavior. *Journal of the Acoustical Society of America* 112(5, Part 2): 2314.

Lenhardt, M. L., S. Bellmund, R. A. Byles, S. W. Harkins, and J. A. Musick, 1983. Marine turtle reception of bone-conducted sound. *Journal of Auditory Research* 23: 119-125.

Lenhardt, M. L., R. C. Klinger, and J. A. Musick, 1985. Marine turtle middle-ear anatomy. *Journal of Auditory Research* 25:66-72.

Leslie, M. S., A. Batibasaga, D. S. Weber, D. Olson, and H. C. Rosenbaum, 2005. First record of Blainville's beaked whale *Mesoplodon densirostris* in Fiji. *Pacific Conservation Biology* 11(4): 302-304.

Lewis, J. A., 1996. *Effects of Underwater Explosions on Life in the Sea*. Department of Defence (Australia), Defence and Science Technology Organisation. August 1996.

Limpus, C. J., 1992. The hawksbill turtle, *Eretmochelys imbricata*, in Queensland: Population structure within a southern Great Barrier Reef ground. *Wildlife Research* 19, 489-506.

Lindstrom, U., and T. Haug, 2001. Feeding strategy and prey selectivity in common minke whales (*Balaenoptera acutorostrata*) foraging in the southern Barents Sea during early summer. *Journal of Cetacean Research and Management* 3(3): 239-250.

Littnan, C., 2011. *Habitat Use and Behavioral Monitoring of Hawaiian Monk Seals in Proximity to the Navy Hawaii Range Complex, Report Period: August 2010-July 2011.* Appendix M, HRC annual monitoring report for 2011, submitted to NMFS.

Littnan, C. L., 2012. *Habitat Use and Behavioral Monitoring of Hawaiian Monk Seals in Proximity to the Navy Hawaii Range Complex*. Annual Report. July 2011 – June 2012. Submitted by Hawaiian Monk Seal Research Program, Ocean Associates, Inc. and SPAWAR Systems Center, Pacific.

Littnan, C. L., B. S. Stewart, P. K. Yochem, and R. Braun, 2007. Survey of selected pathogens and evaluation of disease risk factors for endangered Hawaiian monk seals in the main Hawaiian Islands. *EcoHealth* 3: 232–244.

Lodi, L., and B. Hetzel, 1999. Rough-toothed dolphin, *Steno bredanensis*, feeding behaviors in Ilha Grande Bay, Brazil. *Biociências* 7(1): 29-42.

Lohmann, K. J., and C. M. F. Lohmann, 1992. Orientation to oceanic waves by green sea turtle hatchlings. *Journal of Experimental Biology*, 171, 1-13.

Lohmann, K. J., and C. M. F. Lohmann, 1996. Detection of magnetic field intensity by sea turtles. *Nature*, 380, 59-61. doi:10.1038/380059a0.

Lohmann, K. J., B. E. Witherington, C. M. F. Lohmann, and M. Salmon, 1997. Orientation, navigation, and natal beach homing in sea turtles. In P. L. Lutz and J. A. Musick (eds), *The Biology of Sea Turtles* (pp. 107-136). Boca Raton, FL: CRC Press.

Lusseau, D., and L. Bejder, 2007. The long-term consequences of short-term responses to disturbance experiences from whalewatching impact assessment. *International Journal of Comparative Psychology*, 20(2), 228-236. Retrieved from http://escholarship.org/uc/item/42m224qc.

Lusseau, D., D. E. Bain, R. Williams, and J. C. Smith, 2009. Vessel traffic disrupts the foraging behavior of southern resident killer whales *Orcinus orca*. *Endangered Species Research* 6: 211–221.

Lutcavage, M. E., and P. L. Lutz, 1997. Diving physiology. In P. L. Lutz and J. A. Musick (eds), *The Biology of Sea Turtles* (pp. 277-296). Boca Raton, FL: CRC Press.

MacLeod, C. D., and A. D'Amico, 2006. A review of beaked whale behaviour and ecology in relation to assessing and mitigating impacts of anthropogenic noise. *Journal of Cetacean Research and Management* 7(3): 211-222.

MacLeod, C. D., N. Hauser, and H. Peckham, 2003. Review of data on diets of beaked whales: Evidence of niche separation and geographic segregation. *Journal of the Marine Biological Association of the United Kingdom* 83: 651-665.

MacLeod, C. D., N. Hauser, and H. Peckham, 2004. Diversity, relative density and structure of the cetacean community in summer months east of Great Abaco, Bahamas. *Journal of the Marine Biological Association of the United Kingdom* 84: 469-474.

MacLeod, C. D., and G. Mitchell, 2006. Key areas for beaked whales worldwide. *Journal of Cetacean Research and Management* 7(3): 309-322.

Macleod, C.D., M. P. Simmonds, and E. Murry, 2006a. Abundance of fin (*Balaenoptera physalus*) and sei whales (*B. borealis*) amid oil exploration and development off northwest Scotland. *Journal of Cetacean Research and Management* (3) Vol. 8, pp. 247-254.

MacLeod, C. D., N. Hauser, and H. Peckham, 2006b. Known and inferred distributions of beaked whale species (Ziphiidae: Cetacea). *Journal of Cetacean Research and Management* 7(3): 271-286.

Maison, K. A., I. K. Kelly, and K. P. Frutchey, 2010. *Green Sea Turtle Nesting Sites and Sea Turtle Legislation Throughout Oceania*. NOAA Technical Memorandum NMFS-F/SPO- 110, pp. 56. U.S. Department of Commerce, NOAA, NMFS.

Makowski, C., J. A. Seminoff, and M. Salmon, 2006. Home range and habitat use of juvenile Atlantic green sea turtles (*Chelonia mydas L.*) on shallow reef habitats in Palm Beach, Florida, USA. *Marine Biology*, 148, 1167-1179. doi: 10.1007/s00227-005-0150-y.

Maldini Feinholz, D., 2003. Abundance and distribution patterns of Hawaiian odontocetes: Focus on O‘ahu. Doctoral dissertation. University of Hawaii.

Maldini, D., L. Mazzuca, and S. Atkinson, 2005. Odontocete stranding patterns in the main Hawaiian Islands (1937-2002): How do they compare with live animal surveys? *Pacific Science* 59(1): 55-67.

Marcoux, M., H. Whitehead, and L. Rendell, 2007. Sperm whale feeding variations by location, year, social group and clan: Evidence from stable isotopes. *Marine Ecology Progress Series* 333: 309-314.

Marine Mammal Commission, 2002. Hawaiian monk seal (*Monachus schauinslandi*). *Species of Special Concern, Annual Report to Congress, 2001*. Bethesda, MD, Marine Mammal Commission: 63-76.

Marine Mammal Commission, 2003. Workshop on the Management of Hawaiian Monk Seals on Beaches in the Main Hawaiian Islands: 5.

Márquez M., R., 1990. *FAO Species Catalogue: Sea Turtles of the World, An Annotated and Illustrated Catalogue of Sea Turtle Species Known to Date*. Vol. 11, FAO Fisheries Synopsis. No. 125, pp. 81. Rome, Italy: Food and Agriculture Organization of the United Nations.

Marsh, H. E., 1989. Mass Stranding of dugongs by a tropical cyclone in northern Australia. *Marine Mammal Science* 5(1): 78-84.

Marten, K., 2000. Ultrasonic analysis of pygmy sperm whale (*Kogia breviceps*) and Hubbs' beaked whale (*Mesoplodon carlhubbsi*) clicks. *Aquatic Mammals* 26(1): 45-48.

Marten, K., and S. Psarakos, 1999. Long-term site fidelity and possible long-term associations of wild spinner dolphins (*Stenella longirostris*) seen off Oahu, Hawaii. *Marine Mammal Science* 15(4): 1329-1336.

Martin, S. W., C. R. Martin, B. Matsuyama, and E. E. Henderson, 2015. Minke whales (*Balaenoptera acutorostrata*) respond to Navy training. *Journal of the Acoustical Society of America, 137*(5), 2533–2541. doi: 10.1121/1.4919319.

Martin, C. R., S. W. Martin, E. E. Henderson, T. A. Helble, R. A. Manzano-Roth, and B. M. Matsuyama, 2016. *SSC Pacific FY15 Annual Report on PMRF Marine Mammal Monitoring*.

Masaki, Y., 1976. Biological studies on the North Pacific sei whale. *Bulletin of the Far Seas Fisheries Research Laboratory* 14: 1-104.

Masaki, Y., 1977. The separation of the stock units of sei whales in the North Pacific. *Reports of the International Whaling Commission* (Special Issue 1): 71-79.

Mate, B. R., R. Gisiner, and J. Mobeley, 1998. Local and migratory movements of Hawaiian humpback whales tracked by satellite telemetry. *Canadian Journal of Zoology*, Vol 76, 1998.

Matkin, C. O., E. L. Saulitis, G. M. Ellis, P. Olesiuk, and S. D. Rice, 2008. Ongoing population-level impacts on killer whales *Orcinus orca* following the 'Exxon Valdez' oil spill in Prince William Sound, Alaska. *Marine Ecology Progress Series*, 356, 269-281. doi: 10.3354/meps07273.

McAlpine, D. F., 2009. Pygmy and dwarf sperm whales *Kogia breviceps* and *K. sima*. In W. F. Perrin, B. Wursig and J. G. M. Thewissen (eds), *Encyclopedia of Marine Mammals* (Second Edition). Academic Press: 936-938.

McCauley R. D., J. Fewtrell, A. J. Duncan, C. Jenner, M.-N. Jenner, J. D. Penrose, R. I. T. Prince, A. Adhitya, J. Murdoch, and K. A. McCabe, 2000. *Marine Seismic Surveys: Analysis and Propagation of Air-gun Signals and Effects of Air-gun Exposure on Humpback Whales, Sea Turtles, Fishes and Squid*. Centre for Marine Science and Technology, Western Australia. pp. 198.

McClellan, C. M., and A. J. Read, 2007. Complexity and variation in loggerhead sea turtle life history. *Biology Letters* 3, 592-594. doi: 10.1098/rsbl.2007.0355.

McCracken, M. L., 2000. *Estimation of Sea Turtle Take and Mortality in the Hawaiian Longline Fisheries*. SWFSC Administrative Report H-00-06, pp. 29. Honolulu, HI: Southwest Fisheries Science Center.

McCracken, M. L., and K. A. Forney, 2010. Preliminary assessment of incidental interactions with marine mammals in the Hawaii longline deep and shallow set fisheries. NMFS, PIFSC Working Paper WP-10-001.

McDonald, M., J. Hildebrand, S. Wiggins, and D. Ross, 2008. A 50 year comparison of ambient ocean noise near San Clemente Island: A bathymetrically complex coastal region off Southern California. *Journal of the Acoustical Society of America*: 1985-1992.

McSweeney, D. J., R. W. Baird, and S. D. Mahaffy, 2007. Site fidelity, associations, and movements of Cuvier's (*Ziphius cavirostris*) and Blainville's (*Mesoplodon densirostris*) beaked whales off the Island of Hawaii. Marine *Mammal Science* 23(3): 666-687.

McVey, J. P., and T. Wibbels, 1984. *The Growth and Movements of Captive-Reared Kemp's Ridley Sea Turtles*, Lepidochelys kempii, *Following Their Release in the Gulf of Mexico*. NOAA Technical Memorandum NMFS-SEFC-145, 25p.

Mead, J. G., 1989. Beaked whales of the genus Mesoplodon. In S. H. Ridgway and R. Harrison (eds), *Handbook of Marine Mammals*. San Diego, CA, Academic Press. 4: 349-430.

Mead, J. G., and C. W. Potter, 1995. Recognizing two populations of the bottlenose dolphin (*Tursiops truncatus*) off the Atlantic Coast of North America: Morphologic and ecologic considerations. *IBI Reports* 5: 31-44.

Meylan, A. B., 1988. Spongivory in hawksbill turtles: A diet of glass. *Science*, 239, 393-395.

Meylan, A., 1995. Sea turtle migration evidence from tag returns. In K. A. Bjorndal (ed), *Biology and Conservation of Sea Turtles* (revised ed., pp. 91-100). Washington, D.C.: Smithsonian Institution Press.

Meylan, A. B., and M. Donnelly, 1999. Status justification for listing the hawksbill turtle (*Eretmochelys imbricata*) as critically endangered on the 1996 IUCN Red List of Threatened Animals. *Chelonian Conservation and Biology*, 3(2), 200-224.

Meylan, A. B., 1999. International movements of immature and adult hawksbill turtles (*Eretmochelys imbricata*) in the Caribbean region. *Chelonian Conservation and Biology*, 3(2), 189-194.

Mignucci-Giannoni, A. A., 1998. Zoogeography of cetaceans off Puerto Rico and the Virgin Islands. *Caribbean Journal of Science* 34(3-4): 173-190.

Miller, J. D., C. J. Limpus, and M. H. Godfrey, 2003. Nest site selection, oviposition, eggs, development, hatching, and emergence of loggerhead turtles. In A. B. Bolten and B. E. Witherington (eds), *Loggerhead Sea Turtles* (pp. 125-143). Washington, D.C.: Smithsonian Institution Press.

Miyashita, T., 1993. Distribution and abundance of some dolphins taken in the North Pacific driftnet fisheries. *International North Pacific Fisheries Commission Bulletin* 53(3): 435-450.

Miyashita, T., T. Kishiro, N. Higashi, F. Sato, K. Mori, and H. Kato, 1996. Winter distribution of cetaceans in the western North Pacific inferred from sighting cruises 1993-1995. *Reports of the International Whaling Commission* 46: 437-442.

Miyazaki, N., and W. F. Perrin, 1994. Rough-toothed dolphin *Steno bredanensis* (Lesson, 1828). In S. H. Ridgway and R. Harrison (eds), *Handbook of Marine Mammals*. San Diego, CA, Academic Press. 5: 1-21.

Miyazaki, N., and S. Wada, 1978. Fraser's dolphin, *Lagenodelphis hosei* in the western North Pacific. *Scientific Reports of the Whales Research Institute* 30: 231-244.

Mizroch, S. A., D. W. Rice, D. Zwiefelhofer, J. Waite, and W. L. Perryman, 2009. Distribution and movements of fin whales in the North Pacific Ocean. *Mammal Review* 39: 193-227.

Mobley, J. R., 2004. *Results of Marine Mammal Surveys on U.S. Navy Underwater Ranges in Hawaii and Bahamas: 27*.

Mobley, J. R., 2005. Assessing responses of humpback whales to North Pacific Acoustic Laboratory (NPAL) transmissions: Results of 2001-2003 aerial surveys north of Kauai. *Journal of the Acoustical Society of America* 117: 1666-1773.

Mobley, J. R., Jr., G. B. Bauer, and L. M. Herman, 1999. Changes over a ten-year interval in the distribution and relative abundance of humpback whales (*Megaptera novaeangliae*) wintering in Hawaiian waters. *Aquatic Mammals* 25: 63-72.

Mobley, J. R., Jr., M. Smultea, T. Norris, and D. Weller, 1996. Fin whale sighting north of Kaua'i, Hawai'i. *Pacific Science* 50: 230-233.

Mobley, J. R., Jr., S. S. Spitz, K. A. Forney, R. Grotefendt, and P. H. Forestell, 2000. *Distribution and Abundance of Odontocete Species in Hawaiian Waters: Preliminary Results of 1993-98 Aerial Surveys, Southwest Fisheries Science Center: 26*.

Mobley, J., S. Spitz, and R. Grotefendt, 2001a. *Abundance of Humpback Whales in Hawaiian Waters: Results of 1993-2000 Aerial Surveys, Hawaiian Islands Humpback Whale National Marine Sanctuary, Department of Land and Natural Resources, State of Hawaii: 17*.

Mobley, J. R., Jr., L. Mazzuca, A. S. Craig, M. W. Newcomer, and S. S. Spitz, 2001b. Killer whales (*Orcinus orca*) sighted west of Ni'ihau, Hawai'i. *Pacific Science* 55: 301-303.

Moein Bartol, S. E., J. A. Musick, J. A. Keinath, D. E. Barnard, M. L. Lenhardt, and R. George, 1995. Evaluation of seismic sources for repelling sea turtles from hopper dredges. In L. Z. Hales (ed), *Sea Turtle Research Program: Summary Report*, U.S. Army Engineer Division, South Atlantic, Atlanta, Georgia, and U.S. Naval Submarine Base, Kings Bay, Georgia. pp. 90-93.

Moon, H. B., K. Kannan, M. Choi, J. Yu, H. G. Choi, Y. R. An, Z. G. Kim, 2010. Chlorinated and brominated contaminants including PCBs and PBDEs in minke whales and common dolphins from Korean coastal waters. *Journal of Hazardous Materials*, 179(1-3), 735-741.

Moore, J. C., 1972. More skull characters of the beaked whale *Indopacetus pacificus* and comparative measurements of austral relatives. *Fieldiana Zoology* 62: 1-19.

Moretti, D., T. A. Marques, L. Thomas, N. DiMarzio, A. Dilley, R. Morrissey, E. McCarthy, J. Ward, and S. Jarvis, 2010. A dive counting density estimation method for Blainville's beaked whale (*Mesoplodon densirostris*) using a bottom-mounted hydrophone field as applied to a mid-frequency active (MFA) sonar operation. *Applied Acoustics* 71:1036-1042.

Morreale, S. J., E. A. Standora, J. R. Spotila, and F. V. Paladino, 1996. Migration corridor for sea turtles. *Nature*, 384, 319-320.

Mortimer, J. A., 1995. Feeding ecology of sea turtles. In K. A. Bjorndal (ed), *Biology and Conservation of Sea Turtles* (revised ed., pp. 103-109). Washington, D.C.: Smithsonian Institution Press.

Mortimer, J. A., and R. Bresson, 1999. Temporal distribution and periodicity in hawksbill turtles (*Eretmochelys imbricata*) nesting at Cousin Island, Republic of Seychelles, 1971-1997. *Chelonian Conservation and Biology*, 3(2), 318-325.

Mortimer, J. A., and M. Donnelly, 2008. Hawksbill Turtle (*Eretmochelys imbricata*): Marine Turtle Specialist Group 2008 IUCN Red List Status Assessment. Retrieved from www.iucnredlist.org, 03 September 2009.

Mrosovsky, N., 1980. Thermal biology of sea turtles. *American Zoologist*, 20(3), 531-547.

Mrosovsky, N., and P. C. H. Pritchard, 1971. Body temperatures of *Dermochelys coriacea* and other sea turtles. *Copeia*, 1971(4), 624-631.

Mrosovsky, N., G. D. Ryan, and M. C. James, 2009. Leatherback turtles: The menace of plastic. *Marine Pollution Bulletin*, 58, 287-289.

Musick, J. A., and C. J. Limpus, 1997. Habitat utilization and migration of juvenile sea turtles. In P. L. Lutz and J. A. Musick (eds), *The Biology of Sea Turtles* (pp. 137-163). Boca Raton, FL: CRC Press.

Mussi, B., A. Miragliuolo, T. De Pippo, M. C. Gambi, and D. Chiota, 2004. The submarine canyon of Cuma (southern Tyrrhenian Sea, Italy), a cetacean key area to protect. *European Research on Cetaceans* 15: 178-179.

Muto, M. M., V. T. Helker, R. P. Angliss, B. A. Allen, P. L. Boveng, J. M. Breiwick, M. F. Cameron, P. J. Clapham, S. P. Dahle, M .E. Dahlheim, B. S. Fadely, M. C. Ferguson, L. W. Fritz, R. C. Hobbs, Y. V. Ivashchenko, A. S. Kennedy, J. M. London, S. A. Mizroch, R. R. Ream, E. L. Richmond, K. E. W. Sheldon, R. G. Towell, P. R.

Wade, J. M. Waite, and A. N. Zerbini, 2016. *Alaska Marine Mammal Stock Assessments, 2015*. U.S. Department of Commerce. NOAA Technical Memorandum. NMFS-AFSC-323, 300 p.

Myers, A. E., and G. C. Hays, 2006. Do leatherback turtles *Dermochelys coriacea* forage during the breeding season? A combination of data-logging devices provide new insights. *Marine Ecology Progress Series*, 322, 259-267.

Nachtigall, P. E., J. L. Pawloski, and W. W. L. Au, 2003. Temporary threshold shifts and recovery following noise exposure in the Atlantic bottlenosed dolphin (*Tursiops truncatus*). *Journal of the Acoustical Society of America* 113:3425-3429.

Nachtigall, P. E., A. Y. Supin, J. Pawloski, and W. W. L. Au, 2004. Temporary threshold shifts after noise exposure in the bottlenose dolphin (*Tursiops truncatus*) measured using evoked auditory potentials. *Marine Mammal Science* 20:673–687.

National Cooperative Highway Research Program (NCHRP), 2011. *Hydroacoustic Impacts on Fish from Pile Installation*. October 2011.

National Marine Fisheries Service (NMFS), 1986. Designated Critical Habitat; Hawaiian Monk Seal. Federal Register 51(83): 16047-16053.

National Marine Fisheries Service (NMFS), 1988. Critical Habitat; Hawaiian Monk Seal; Endangered Species Act. Federal Register 53(102): 18988-18998.

National Marine Fisheries Service (NMFS), 2001. *Stock Assessments of Loggerhead and Leatherback Sea Turtles and an Assessment of the Impact of the Pelagic Longline Fishery on the Loggerhead and Leatherback Sea Turtles of the Western North Atlantic*. NOAA Technical Memorandum NMFS-SEFSC-455, pp. 343. U.S. Department of Commerce. Southeast Fisheries Science Center.

National Marine Fisheries Service (NMFS), 2004. *Cause of Stranding Database for Marine Turtle Strandings in the Hawaiian Islands, 1982-2003*. Vol. 154. Honolulu, HI: NMFS Pacific Islands Fisheries Science Center.

National Marine Fisheries Service (NMFS), 2007a. *Pacific Islands Region, Marine Mammal Response Network Activity Update #5*.

National Marine Fisheries Service (NMFS), 2007b. *Recovery Plan for the Hawaiian Monk Seal (*Monachus schauinslandi*)*. Silver Spring, MD, NMFS: 165.

National Marine Fisheries Service (NMFS), 2008. *Pacific Islands Region, Marine Mammal Response Network Activity Update #8.*

National Marine Fisheries Service (NMFS), 2009. Taking and Importing of Marine Mammals; U.S. Navy Training in the Hawaii Range Complex; Final Rule. Federal Register, Monday, January 12, 2009, 74(7):1456-1491.

National Marine Fisheries Service (NMFS), 2010a. *Pacific Islands Region, Marine Mammal Response Network Activity Update #14*. pp. 6.

National Marine Fisheries Service (NMFS), 2010b. *Pacific Islands Regional Office, Hawaiian Monk Seal Top Threats*.

National Marine Fisheries Service (NMFS), 2010c. *Pacific Islands Regional Office, Hawaiian Monk Seal Population and Location*.

National Marine Fisheries Service (NMFS), 2010d. Marine Turtles. Office of Protected Resources. Retrieved from http://www.nmfs.noaa.gov/pr/species/turtles/, 25 May 2010.

National Marine Fisheries Service (NMFS), 2010e. Pacific Islands Region, Marine Mammal Response Network Activity Update #14 (pp. 6). Accessed online at http://www.fpir.noaa.gov/Library/PRD/Marine%20 Mammal%20Response/MMRN_14-newsletter.KU.7-21-10.pdf.

National Marine Fisheries Service (NMFS), 2010f. Pacific Islands Region, Marine Mammal Response Network Activity Update #15 (pp. 5). Accessed online at http://www.fpir.noaa.gov/Library/PRD/Marine%20Mammal %20Response/MMRN_15-newsletter.12-21.pdf.

National Marine Fisheries Service (NMFS), 2011a. *Pacific Islands Region, Marine Mammal Response Network Activity Update #17*.

National Marine Fisheries Service (NMFS), 2011b. Pacific Science Center Stranding Data. Excel file containing stranding from the Hawaiian Islands, manuscript on file.

National Marine Fisheries Service (NMFS), 2011c. Hawaii Longline Deep Set Quarterly and Annual Status Reports, 2004-2011. Retrieved from: http://www.fpir.noaa.gov/OBS/obs_hi_ll_ds_rprts.html.

National Marine Fisheries Service (NMFS), 2012. Endangered and Threatened Wildlife and Plants; Endangered Status for the Main Hawaiian Islands Insular False Killer Whale Distinct Population Segment. Federal Register, 77(229), 70915-70939.

National Marine Fisheries Service (NMFS), 2014. *Final Programmatic Environmental Impact Statement for Hawaii Monk Seal Recovery Actions*. March 2014.

National Marine Fisheries Service (NMFS), 2015. Hawaiian Monk Seal (*Neomonachus schauinslandi*). Information last updated on August 21, 2015, and accessed at http://www.fisheries.noaa.gov/pr/species/ mammals/seals/hawaiian-monk-seal.html. Information accessed on January 26, 2016.

National Marine Fisheries Service (NMFS), 2016. Species in the Spotlight. Priority Actions: 2016-2020. Hawaiian Monk Seal *Neomonachus schauinslandi*. NOAA Fisheries. *Hawaiian Monk Seal 5-Year Action Plan*. January 2016.

National Marine Fisheries Service (NMFS), 2016a. NMFS Landings Query Results. Accessed online at http://www.st.nmfs.noaa.gov/pls/webpls/MF_ANNUAL_LANDINGS.RESULTS on January 11, 2016.

National Marine Fisheries Service (NMFS), 2016b. Landings by Distance from U.S. Shores, 2012, State of Hawaii. Accessed online at http://www.st.nmfs.noaa.gov/pls/webpls/mf_8850_landings.results?qstate=14 on January 11, 2016.

National Marine Fisheries Service (NMFS) 2016c. MRIP Query Output. Personal communication from the National Marine Fisheries Service, Fisheries Statistics Division. January 14, 2016.

National Marine Fisheries Service (NMFS), 2016d. *Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing: Underwater Acoustic Thresholds for Onset of Permanent and Temporary Threshold Shifts*. U.S. Department of Commerce, National Oceanic and Atmospheric Administration (NOAA). NOAA Technical Memorandum NMFS-OPR-55, 178 p.

National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS), 1991. *Recovery Plan for U.S. Populations of Atlantic Green Sea Turtle* Chelonia mydas. pp. 52. Washington, D.C.: NMFS.

National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS), 1992. *Recovery Plan for Leatherback Turtles* Dermochelys coriacea *in the U.S. Carribean, Atlantic and Gulf of Mexico*. pp. 65. Silver Spring, MD: NMFS.

National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS), 1998a. *Recovery Plan for U.S. Pacific Populations of the Green Sea Turtle (*Chelonia mydas*).* pp. 84. Silver Spring, MD: NMFS.

National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS), 1998b. *Recovery Plan for U.S. Pacific Populations of the Hawksbill Turtle (*Eretmochelys imbricata*).* pp. 83. Silver Spring, MD: NMFS.

National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS), 1998c. *Recovery Plan for U.S. Pacific Populations of the Loggerhead Turtle (*Caretta caretta*).* pp. 59. Silver Spring, MD: NMFS.

National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS), 1998d. *Recovery Plan for U.S. Pacific Populations of the Olive Ridley Turtle (*Lepidochelys olivacea*).* pp. 52. Silver Spring, MD: NMFS.

National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS), 1998e. *Recovery Plan for U.S. Pacific Populations of the Leatherback Turtle (*Dermochelys coriacea*).* pp. 65. Silver Spring, MD: NMFS.

National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS), 2007a. *Green Sea Turtle (*Chelonia mydas*) 5-Year Review: Summary and Evaluation*. pp. 102. Silver Spring, MD: NMFS.

National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS), 2007b. *Leatherback Sea Turtle (*Dermochelys coriacea*) 5-Year Review: Summary and Evaluation*. pp. 79. Silver Spring, MD: National Marine Fisheries.

National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS), 2007c. *Hawksbill Sea Turtle (*Eretmochelys imbricata*) 5-Year Review: Summary and Evaluation*. pp. 90. Silver Spring, MD: NMFS.

National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS), 2007d. *Loggerhead Sea Turtle (*Caretta caretta*) 5-Year Review: Summary and Evaluation*. pp. 65. Silver Spring, MD: NMFS.

National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS), 2007e. *Olive Ridley Sea Turtle (*Lepidochelys olivacea*) 5-Year Review: Summary and Evaluation*. pp. 64. Silver Spring, MD: NMFS.

National Oceanic and Atmospheric Administration (NOAA), 1996. Magnuson Act Provisions; Consolidation and Update of Regulations. Proposed rule; request for comments. Federal Register, 61(85), 19390-19429.

National Oceanic and Atmospheric Administration (NOAA) 2000. *The Economic Contribution of Whalewatching to Regional Economics: Perspectives from Two National Marine Sanctuaries*. Marine Sanctuaries Conservation Series MSD-00-2. July 2000.

National Oceanic and Atmospheric Administration (NOAA), 2010. *Hawaiian Islands Humpback Whale National Marine Sanctuary Condition Report 2010*. August 2010.

National Oceanic and Atmospheric Administration (NOAA), 2012. *Hawaii Charter Cost-Earnings Survey 2012: Preliminary Results*.

National Oceanographic and Atmospheric Administration (NOAA), 2014. NOAA Fisheries Protected Resources. Accessed from http://www.nmfs.noaa.gov/pr/species/mammals/cetaceans/minkewhale.htm. Last updated on June 26, 2014. Accessed on February 18, 2016.

National Oceanographic and Atmospheric Administration (NOAA), 2016a. Maritime Heritage Program, Pacific Island Region. Accessed from http://www.papahanaumokuakea.gov/pdf/pacific_mhp.pdf. Accessed on January 27.

National Oceanographic and Atmospheric Administration (NOAA), 2016b. Maritime History. Accessed from http://hawaiihumpbackwhale.noaa.gov/maritime/maritime_history.html, January 27.

National Oceanographic and Atmospheric Administration (NOAA), 2016c. Automated Wreck and Obstruction Information System Database (AWOIS). Accessed from http://www.nauticalcharts.noaa.gov/hsd/wrecks_and_obstructions.html. January 26.

National Research Council, 2003. Ocean Noise and Marine Mammals. pp. 219. Washington, D.C.: National Academies Press.

National Research Council, 2005. Marine Mammal Populations and Ocean Noise. Washington, D.C.: National Academies Press.

National Research Council, 2010. *Assessment of Sea-Turtle Status and Trends: Integrating Demography and Abundance. Committee on the Review of Sea-Turtle Population Assessment Methods Ocean Studies Board Division on Earth and Life Studies*. The National Academies Press. Washington, D.C.

National Research Council of the National Academies, 2005. *Marine Mammal Populations and Ocean Noise Determining when Noise Causes Biologically Significant Effects*. Washington DC: The National Academies Press.

Natoli, A., V. M. Peddemors, and A. R. Hoelzel, 2004. Population structure and speciation in the genus Tursiops based on microsatellite and mitochondrial DNA analyses. *Journal of Evolutionary Biology* 17: 363-375.

Naval Surface Warfare Center, 1975. *A Chemical Monitoring Program of the Explosion Products in Underwater Explosion Tests*. NSWC Technical Report NSWC/WOL/TR. Naval Surface Weapons Center, White Oak Laboratory, Silver Spring, MD. 4 April 1975.

Neill, W. H., and E. D. Stevens, 1974. Thermal inertia versus thermoregulation in “warm” turtles and tunas. *Science*, 184, 1008-1010.

Nemoto, T., and A. Kawamura, 1977. Characteristics of food habits and distribution of baleen whales with special reference to the abundance of North Pacific sei and Bryde’s whales. *Reports of the International Whaling Commission* Special Issue 1: 80-87.

Norman, S. A., C. E. Bowlby, M. S. Brancato, J. Calambokidis, D. Duffield, P. J. Gearin, T. A. Gornall, M. E. Gosho, B. Hanson, J. Hodder, S. J. Jeffries, B. Lagerquist, D. M. Lambourn, B. Mate, B. Norberg, R. W. Osborne, J. A. Rash, S. Riemer, and J. Scordino, 2004. Cetacean strandings in Oregon and Washington between 1930 and 2002. *Journal of Cetacean Research and Management* 6(1): 87-99.

Norris, K. S., and T. P. Dohl, 1980. Behavior of the Hawaiian spinner dolphin, *Stenella longirostris*. *Fishery Bulletin* 77: 821-849.

Norris, T. F., M. McDonald, and J. Barlow, 1999. Acoustic detections of singing humpback whales (*Megaptera novaeangliae*) in the eastern North Pacific during their northbound migration. *Journal of the Acoustical Society of America* 106(1): 506-514.

Norris, T. F., M. A. Smultea, A. M. Zoidis, S. Rankin, C. Loftus, C. Oedekoven, J. L. Hayes, and E. Silva, 2005. *A Preliminary Acoustic-Visual Survey of Cetaceans in Deep Waters around Ni‘ihau, Kaua‘i, and Portions of O‘ahu, Hawai‘i from Aboard the R/V Dariabar*. Bar Harbor, ME: 75.

Norris, K. S., B. Wursig, R. S. Wells, and M. Wursig, 1994. *The Hawaiian Spinner Dolphin*. Berkeley, CA, University of California Press: 408.

Northridge, S., 2008. Fishing industry, effects of. In W. F. Perrin, B. Wursig, and J. G. M. Thewissen (eds), *Encyclopedia of Marine Mammals*. San Diego, CA, Academic Press: 443-447.

Nowacek, D., L. H. Thorne, D. Johnston, and P. Tyack, 2007. Responses of cetaceans to anthropogenic noise. *Mammal Review* 37(2): 81-115.

Okamura, H., A. Yatsu, T. Miyashita, and S. Kawahara, 2001. The development of the ecosystem model for the western North Pacific area off Japan. Paper SC/53/O9 presented to the IWC Scientific Committee, July, Hammersmith (unpublished), 36pp.

O'Keefe, D. J., and G. A. Young, 1984. *Handbook on the Environmental Effects of Underwater Explosions*. Naval Surface Weapons Center, Dahlgren, Virginia. September 13.

O'Keefe, D. J., and G. A. Young, 1984. *Handbook on the Environmental Effects of Underwater Explosions*. Naval Surface Weapons Center, Dahlgren, Virginia. September 13.

Odell, D. K., and K. M. McClune, 1999. False killer whale -- *Pseudorca crassidens* (Owen, 1846). In S. H. Ridgway and S. R. Harrison (eds), *Handbook of Marine Mammals, Vol. 6: The Second Book of Dolphins and the Porpoises*. New York, Academic Press.

O'Hara, J., and J. R. Wilcox, 1990. Avoidance responses of loggerhead turtles, *Caretta caretta*, to low frequency sound. *Copeia* 2:564-567.

Ohizumi, H., and T. Kishiro, 2003. Stomach contents of a Cuvier's beaked whale (*Ziphius cavirostris*) stranded on the central Pacific coast of Japan. *Aquatic Mammals* 29(1): 99-103.

Ohizumi, H., T. Matsuishi, and H. Kishino, 2002. Winter sightings of humpback and Bryde's whales in tropical waters of the western and central North Pacific. *Aquatic Mammals* 28(1): 73-77.

Okamura, H., A. Yatsu, T. Miyashita, and S. Kawahara, 2001. The development of the ecosystem model for the western North Pacific area off Japan. Paper SC/53/O9 presented to IWC Scientific Committee, London. Available from the office of the IWC.

Okuyama, J., S. Tomohito, O. Abe, K. Yoseda, and N. Arai, 2010. Wild versus head-started hawksbill turtles *Eretmochelys imbricata*: Post-release behavior and feeding adaptions. *Endangered Species Research*, January 2010.

Oleson, E. M., C. H. Boggs, K. A. Forney, B. Hanson, D. R. Kobayashi, B. L. Taylor, P. Wade, and G. M. Ylitalo, 2010. *Status Review of Hawaiian Insular False Killer Whales (*Pseudorca crassidens*) Under the Endangered Species Act.* U.S. Department of Commerce and NOAA: 140 + appendices.

Oleson, E., and M. Hill, 2009. *Report to PACFLT: Data Collection and Preliminary Results from the Main Hawaiian Islands Cetacean Assessment Survey & Cetacean Monitoring Associated with Explosives Training off Oahu, 2010 Annual Range Complex Monitoring Report for Hawaii and Southern California*.

Olson, P. A., 2009. Pilot whales *Globicephala melas* and *G. macrorhynchus*. In W. F. Perrin, B. Würsig and J. G. M. Thewissen (eds), *Encyclopedia of Marine Mammals*. San Diego, CA, Academic Press: 898-903.

O'Malley, A. E., 2010. The Navy's Nature Guy. Midweek Kaua'i. Retrieved from http://www.midweekkauai.com/2010/09/the-navys-nature-guy.

Östman-Lind, J., A. D. Driscoll-Lind, and S. H. Rickards, 2004. *Delphinid Abundance, Distribution and Habitat Use off the Western Coast of the Island of Hawaii*. La Jolla, CA, NMFS.

Oswald, J. N., J. Barlow, and T. F. Norris, 2003. Acoustic identification of nine delphinid species in the eastern tropical Pacific Ocean. *Marine Mammal Science* 19(1): 20-37.

Paladino, F. V., M. P. O'Connor, and J. R. Spotila, 1990. Metabolism of leatherback turtles, gigantothermy and thermoregulation of dinosaurs. *Nature*, 344, 858-860.

Panigada, S., M. Zanardelli, M. Mackenzie, C. Donovan, F. Melin, and P. Hammond, 2008. Modelling habitat preferences for fin whales and striped dolphins in the Pelagos Sanctuary (Western Mediterranean Sea) with physiographic and remote sensing variables. *Remote Sensing of Environment* 112(8): 3400-3412.

Paniz-Mondolfi, A. E., and L. Sander-Hoffmann, 2009. Lobomycosis in inshore and estuarine dolphins. *Emerging Infectious Diseases* 15(4): 672-673.

Parker, D. M., and G. H. Balazs, 2005. Diet of the oceanic green sea turtle, *Chelonia mydas*, in the north Pacific. In H. Kalb, A. S. Rohde, K. Gayheart, and K. Shanker (eds), *Proceedings of the Twenty-Fifth Annual Symposium on Sea Turtle Biology and Conservation*. Abstract. NOAA Technical Memorandum NMFS-SEFSC-582, pp. 94. U.S. Department of Commerce, NOAA, NMFS.

Parker, D. M., G. H. Balazs, C. S. King, L. Katahira, and W. Gilmartin, 2009. Short-range movements of hawksbill turtles (*Eretmochelys imbricata*) from nesting to foraging areas within the Hawaiian Islands. *Pacific Science*, 63(3), 371-382.

Parker, D. M., P. H. Dutton, K. Kopitsky, and R. L. Pitman, 2003. Movement and dive behavior determined by satellite telemetry for male and female olive ridley turtles in the Eastern Tropical Pacific. In J. A. Seminoff (ed), *Proceedings of the Twenty-Second Annual Symposium on Sea Turtle Biology and Conservation.* Abstract. NOAA Technical Memorandum NMFS-SEFSC-503, pp. 48-49. U.S. Department of Commerce, NOAA, NMFS. Available from http://www.nmfs.noaa.gov/pr/species/turtles/symposia.htm.

Parker, L. G., 1995. Encounter with a juvenile hawksbill turtle offshore Sapelo Island, Georgia. *Marine Turtle Newsletter*, 71, 19-22. Retrieved from http://www.seaturtle.org/mtn/archives/mtn71/mtn71p19.shtml.

Parrish, F. A., M. P. Craig, T. J. Ragen, G. J. Marshall, and B. M. Buhleier, 2000. Identifying diurnal foraging habitat of endangered Hawaiian monk seals using a seal-mounted video camera. *Marine Mammal Science* 16(2): 392-412.

Parrish, F. A., G. J. Marshall, B. Buhleier, and G. A. Antonelis, 2008. Foraging interaction between monk seals and large predatory fish in the Northwestern Hawaiian Islands. *Endangered Species Research* 4(3): 299-308.

Payne, P. M., and D. W. Heinemann, 1993. The distribution of pilot whales (*Globicephala* spp.) in shelf/shelf edge and slope waters of the northeastern United States, 1978-1988. *Reports of the International Whaling Commission* Special Issue 14: 51-68.

Pelletier, D., D. Roos, and S. Ciccione, 2003. Oceanic survival and movements of wild and captive-reared immature green sea turtles (*Chelonia mydas*) in the Indian Ocean. *Aquatic Living Resources*, 16, 35-41. doi: 10.1016/S0990-7440(03)00005-6.

Pennington, J. C., T. F. Jenkins, G. Ampleman, S. Thiboutot, J. M. Brannon, A. D. Hewitt, J. Lewis, S. Brochu, E. Diaz, M. R. Walsh, M. E. Walsh, S. Taylor, J. C. Lynch, J. Clausen, T. A. Ranney, C. A. Ramsey, C. A. Hayes, C. L. Grant, C. M. Collins, S. R. Bigl, S. Yost, and K. Dontsova, 2006. *Distribution and Fate of Energetics on DoD Test and Training Ranges: Final Report*. U.S. Army Corps of Engineers ERDC TR-06-13. November 2006.

Perkins, J. S., and G. W. Miller, 1983. Mass stranding of *Steno bredanensis* in Belize. *Biotropica* 15(3): 235-236.

Perrin, W. F., 1976. First record of the melon-headed whale, *Peponocephala electra*, in the eastern Pacific, with a summary of world distribution. *Fishery Bulletin* 74(2): 457-458.

Perrin, W. F., 2001. Stenella attenuata. *Mammalian Species* 683: 1-8.

Perrin, W. F., 2008a. Pantropical spotted dolphin *Stenella attenuata*. In W. F. Perrin, B. Wursig, and J. G. M. Thewissen (eds), *Encyclopedia of Marine Mammals*. Academic Press: 819-821.

Perrin, W. F., 2008b. Spinner dolphin *Stenella longirostris*. In W. F. Perrin, B. Wursig, and J. G. M. Thewissen (eds), *Encyclopedia of Marine Mammals*. Academic Press: 1100-1103.

Perrin, W. F., P. B. Best, W. H. Dawbin, K. C. Balcomb, R. Gambell, and G. J. B. Ross, 1973. Rediscovery of Fraser's dolphin *Lagenodelphis hosei*. *Nature* 241: 345-350.

Perrin, W. F., and A. A. Hohn, 1994. Pantropical spotted dolphin *Stenella attenuata*. In S. H. Ridgway and R. Harrison (eds), *Handbook of Marine Mammals*. San Diego, CA, Academic Press. 5: 71-98.

Perrin, W. F., and J. W. Gilpatrick, Jr., 1994. Spinner dolphin *Stenella longirostris* (Gray, 1828). In S. H. Ridgway and R. Harrison (eds), *Handbook of Marine Mammals, Volume 5: The first book of dolphins*. San Diego, CA, Academic Press. 5: 99-128.

Perrin, W. F., C. E. Wilson, and F. I. Archer II, 1994a. Striped dolphin--*Stenella coeruleoalba* (Meyen, 1833). In S. H. Ridgway and R. Harrison (eds), *Handbook of Marine Mammals*. San Diego, CA, Academic Press. 5: The First Book of Dolphins: 129-159.

Perrin, W. F., S. Leatherwood, and A. Collet, 1994b. Fraser's dolphin *Lagenodelphis hosei* Fraser, 1956. In S. H. Ridgway and R. Harrison (eds), *Handbook of Marine Mammals, Volume 5: The first book of dolphins*. San Diego, California, Academic Press: 225-240.

Perrin, W. F., B. Würsig, and J. G. M. Thewissen, 2009. *Encyclopedia of Marine Mammals*. Second Edition. Academic Press, Amsterdam.

Perry, S. L., D. P. DeMaster, and G. K. Silber, 1999. The great whales: history and status of six species listed as Endangered under the U.S. Endangered Species Act of 1973. *Marine Fisheries Review* 61(1): 1-74.

Perryman, W. L., 2008. Melon-headed whale *Peponocephala electra*. In W. F. Perrin, B. Wursig and J. G. M. Thewissen (eds), *Encyclopedia of Marine Mammals*. Academic Press: 719-721.

Perryman, W. L., D. W. K. Au, S. Leatherwood, and T. A. Jefferson, 1994. Melon-headed whale *Peponocephala electra* Gray, 1846. In S. H. Ridgway and R. Harrison (eds), *Handbook of Marine Mammals, Volume 5: The first book of dolphins*, Academic Press: 363-386.

Perryman, W. L., and T. C. Foster, 1980. *Preliminary Report on Predation by Small Whales, Mainly the False Killer Whale,* Pseudorca crassidens, *on Dolphins (*Stenella *spp.* and Delphinus delphis*) in the Eastern Tropical Pacific*. La Jolla, CA, U.S. Department of Commerce, NOAA, NMFS, Southwest Fisheries Science Center: 9.

Pierce, G., M. Santos, C. Smeenk, A. Saveliev, and A. Zuur, 2007. Historical trends in the incidence of strandings of sperm whales (*Physeter macrocephalus*) on North Sea coasts: An association with positive temperature anomalies. *Fisheries Research* 87(2-3): 219-228.

Pitman, R., 2008. Indo-Pacific beaked whale *Indopacetus pacificus*. In W. F. Perrin, B. Wursig and J. G. M. Thewissen (eds), *Encyclopedia of Marine Mammals*, Academic Press: 600-602.

Pitman, R. L., 1990. Pelagic distribution and biology of sea turtles in the eastern tropical Pacific. In T. H. Richardson, J. I. Richardson and M. Donnelly (eds), *Proceedings of the Tenth Annual Workshop on Sea Turtle Biology and Conservation*. NOAA Technical Memorandum NMFS-SEFC-278, pp. 143-150. U.S. Department of Commerce, NOAA, NMFS.

Pitman, R. L., 1992. Sea turtle associations with flotsam in the eastern tropical Pacific Ocean. In M. Salmon and J. Wyneken (eds), *Proceedings of the Eleventh Annual Workshop on Sea Turtle Biology and Conservation*.

Abstract. NOAA Technical Memorandum NMFS-SEFSC-302, pp. 94. U.S. Department of Commerce, NOAA, NMFS.

Pitman, R. L., D. W. K. Au, M. D. Scott, and J. M. Cotton, 1988. *Observations of Beaked Whales (*Ziphiidae*) from the Eastern Tropical Pacific Ocean*. International Whaling Commission.

Pitman, R. L., H. Fearnbach, R. LeDuc, J. W. Gilpatrick, Jr., J. K. B. Ford, and L. T. Ballance, 2007. Killer whales preying on a blue whale calf on the Costa Rica Dome: Genetics, morphometrics, vocalisations and composition of the group. *Journal of Cetacean Research and Management* 9(2): 151-157.

Pitman, R. L., and C. Stinchcomb, 2002. Rough-toothed dolphins (*Steno bredanensis*) as predators of mahi mahi (*Coryphaena hippurus*). *Pacific Science* 56(4): 447-450.

Polovina, J. J., G. H. Balazs, E. A. Howell, D. M. Parker, M. P. Seki, and P. H. Dutton, 2004. Forage and migration habitat of loggerhead (*Caretta caretta*) and olive ridley (*Lepidochelys olivacea*) sea turtles in the central North Pacific Ocean. *Fisheries Oceanography*, 13(1), 36-51.

Plotkin, P. T., R. A. Byles, and D. W. Owens, 1994. Post-breeding movements of male olive ridley sea turtles *Lepidochelys olivacea* from a nearshore breeding area. In K. A. Bjorndal, A. B. Bolton, D. A. Johnson, and P. J. Eliazar (eds), *Proceedings of the Fourteenth Annual Symposium on Sea Turtle Biology and Conservation*. Abstract. NOAA Technical Memorandum NMFC-SEFSC-351. U.S. Department of Commerce, NOAA, NMFS.

Polovina, J. J., E. Howell, D. R. Kobayashi, and M. P. Seki, 2001. The transition zone chlorophyll front, a dynamic global feature defining migration and forage habitat for marine resources. *Progress in Oceanography*, 49, 469-483.

Polovina, J. J., E. Howell, D. M. Parker, and G. H. Balazs, 2002. Dive-depth distribution of loggerhead (*Caretta caretta*) and olive ridley (*Lepidochelys olivacea*) sea turtles in the central North Pacific: Might deep longline sets catch fewer turtles? *Fishery Bulletin*, 101(1), 189-193.

Polovina, J. J., D. R. Kobayashi, D. M. Parker, M. P. Seki, and G. H. Balazs, 2000. Turtles on the edge: movement of loggerhead turtles (*Caretta caretta*) along oceanic fronts, spanning longline fishing grounds in the central North Pacific, 1997-1998. *Fisheries Oceanography*, 9(1), 71-82.

Polovina, J. J., I. Uchida, G. H. Balazs, E. Howell, D. M. Parker, and P. Dutton, 2006. The Kuroshio Extension Bifurcation Region: A pelagic hotspot for juvenile loggerhead sea turtles. *Deep-Sea Research II*, 53, 326-339. doi: 10.1016/j.dsr2.2006.01.006.

Poole, M. M., 1995. Aspects of the behavioral ecology of spinner dolphins (*Stenella longirostris*) in the nearshore waters of Moʻorea, French Polynesia. Doctoral dissertation, University of California, Santa Cruz.

Popper, A. N., and M. C. Hastings, 2009. Review paper: The effects of anthropogenic sources of sound on fishes. *Journal of Fish Biology* (2009) 75, 455-489.

Pritchard, P. C. H., 1997. Evolution, phylogeny, and current status. In P. L. Lutz and J. A. Musick (eds), *The Biology of Sea Turtles* (pp. 1-28). Boca Raton, FL: CRC Press.

Pritchard, P. C. H., 1982. Nesting of the leatherback turtle, *Dermochelys coriacea*, in Pacific Mexico, with a new estimate of the world population status. *Copeia*, 1982(4), 741-747.

Pritchard, P. C. H., and P. T. Plotkin, 1995. Olive ridley sea turtle, *Lepidochelys olivacea*. In P. T. Plotkin (ed), *NMFS and USFWS Status Reviews of Sea Turtles Listed under the Endangered Species Act of 1973*. pp. 123-139. Silver Spring, MD: NMFS.

Pryor, T., K. Pryor, and K. S. Norris, 1965. Observations on a pygmy killer whale (*Feresa attenuata* Gray) from Hawaii. *Journal of Mammalogy* 46(3): 450-461.

RAND Corporation, 2005. *Unexploded Ordnance Cleanup Costs, Implications of Alternative Protocols*.

Rankin, S., and J. Barlow, 2005. Source of the North Pacific “boing” sound attributed to minke whales. *Journal of the Acoustical Society of America* 118: 3346-3351.

Rankin, S., and J. Barlow, 2007. Sounds recorded in the presence of Blainville’s beaked whales, *Mesoplodon densirostris*, near Hawaii (L). *Journal of the Acoustical Society of America* 122(1): 42-45.

Rankin, S., T. F. Norris, M. A. Smultea, C. Oedekoven, A. M. Zoidis, E. Silva, and J. Rivers, 2007. A visual sighting and acoustic detections of minke whales, *Balaenoptera acutorostrata* (Cetacea: Balaenopteridae), in nearshore Hawaiian waters. *Pacific Science* 61: 395-398.

Read, A. J., 2008. The looming crisis: Interactions between marine mammals and fisheries. *Journal of Mammalogy* 89(3): 541-548.

Reeves, R., S. Leatherwood, and R. Baird, 2009. Evidence of a possible decline since 1989 in false killer whales (*Pseudorca crassidens*) around the main Hawaiian Islands. *Pacific Science* 63: 253-261.

Reeves, R. R., W. F. Perrin, B. L. Taylor, C. S. Baker, and S. L. Mesnick, 2004. *Report of the Workshop on Shortcomings of Cetacean Taxonomy in Relation to Needs of Conservation and Management, April 30 - May 2, 2004.* La Jolla, California. U.S. Department of Commerce, NOAA, NMFS, Southwest Fisheries Science Center: 94.

Reeves, R. R., B. S. Stewart, P. J. Clapham, and J. A. Powell, 2002. *National Audubon Society Guide to Marine Mammals of the World*. New York, NY, Alfred A. Knopf: 527.

Reich, K. J., K. A. Bjorndal, A. B. Bolten, and B. Witherington, 2007. Do some loggerheads nesting in Florida have an oceanic foraging strategy? An assessment based on stable isotopes. In R. B. Mast, B. J. Hutchinson, and A. H. Hutchinson (eds), *Proceedings of the Twenty-fourth Annual Symposium on Sea Turtle Biology and Conservation.* Abstract. NOAA Technical Memorandum NMFS-SEFSC-567, pp. 32. U.S. Department of Commerce, NOAA, NMFS.

Reilly, S. B., 1990. Seasonal changes in distribution and habitat differences among dolphins in the eastern tropical Pacific. *Marine Ecology Progress Series* 66: 1-11.

Reilly, S. B., J. L. Bannister, P. B. Best, M. Brown, R. L. Brownell, Jr., D. S. Butterworth, P. J. Clapham, J. Cooke, G. P. Donovan, J. Urbán, and A. N. Zerbini, 2008. *Eubalaena japonica*. In *IUCN 2012, IUCN Red List of Threatened Species*. Version 2012.1. <www.iucnredlist.org>. Downloaded on 29 September 2012.

Renaud, M. L., and J. A. Carpenter, 1994. Movements and submergence patterns of loggerhead turtles (*Caretta caretta*) in the Gulf of Mexico determined through satellite telemetry. *Bulletin of Marine Science*, 55(1), 1-15.

Resendiz, A., B. Resendiz, W. J. Nichols, J. A. Seminoff, and N. Kamezaki, 1998. First confirmed east-west transpacific movement of a loggerhead sea turtle, *Caretta caretta*, released in Baja California, Mexico. *Pacific Science*, 52(2), 151-153.

Reuland, K., 2010. *Habitat Use and Behvaioral Monitoring of Hawaiian Monk Seals in Proximity to the Navy Hawaii Range Complex, Annual Range Complex Monitoring Report for Hawaii and Southern California*.

Rice, D. W., 1989. Sperm whale *Physeter macrocephalus* Linnaeus, 1758. In S. H. Ridgway and R. Harrison (eds), *Handbook of Marine Mammals, Volume 4: River dolphins and the larger toothed whales*. San Diego, CA, Academic Press. 4: 177-234.

Rice, D. W., 1998. Marine mammals of the world: systematics and distribution. *Society for Marine Mammalogy*: 231. Lawrence, KS.

Rice, M. R., and G. H. Balazs, 2008. Diving behavior of the Hawaiian green sea turtle (*Chelonia mydas*) during oceanic migrations. *Journal of Experimental Marine Biology and Ecology*, 356(1-2), 121-127. doi: 10.1016/j.jembe.2007.12.010.

Richardson, J. I., R. Bell, and T. H. Richardson, 1999. Population ecology and demographic implications drawn from an 11-year study of nesting hawksbill turtles, *Eretmochelys imbricata*, at Jumby Bay, Long Island, Antigua, West Indies. *Chelonian Conservation and Biology* 3(2): 244-250.

Richmond, D. R., J. T. Yelverton, and E. R. Fletcher, 1973. Far-field underwater-blast injuries produced by small charges. Washington, DC, Lovelace Foundation for Medical Education and Research, Defense Nuclear Agency: 108.

Ridgway, S. H., and M. D. Dailey, 1972. Cerebral and cerebellar involvement of trematode parasites in dolphins and their possible role in stranding. *Journal of Wildlife Diseases*, *8*, 33–43.

Ridgway, S. H., E. G. Wever, J. G. McCormick, J. Palin, and J. H. Anderson, 1969. Hearing in the giant sea turtle, *Chelonia mydas*. *Proceedings of the National Academy of Sciences USA* 64:884-890.

Ritter, F., 2002. Behavioural observations of rough-toothed dolphins (*Steno bredanensis*) off La Gomera, Canary Islands (1995-2000), with special reference to their interactions with humans. *Aquatic Mammals* 28(1): 46-59.

Rivers, J., 2011. Sea turtles nesting and in-water sightings in the Hawaiian Islands. Personal communication with Julie Rivers, Pacific Fleet Marine Biologist via comments on the HSTT DEIS v1.

Robertson, K. M., and S. J. Chivers, 1997. Prey occurrence in pantropical spotted dolphins, Stenella attenuata, from the eastern tropical Pacific. *Fishery Bulletin* 95(2): 334-348.

Rodacy, P. J., P. K. Walker, S. D. Reber, J. Phelan, and J. V. Andre, 2000. *Explosive Detection in the Marine Environment and on Land Using Ion Mobility Spectroscopy: A Summary of Field Tests*. Sandia National Laboratories. Sandia Report SAND2000-0921. April 2000.

Rolland, R.M, Susan E. Parks, Kathleen E. Hunt, Manuel Castellote, Peter J. Corkeron, Douglas P. Nowacek, Samuel K. Wasser, and Scott D. Kraus, 2012. Evidence that ship noise increases stress in right whales. *Proc. R. Soc. B Biological Sciences* 279, 2363-2368. doi: 10.1098/rspb.2011.2429.

Rosel, P. E., and H. Watts, 2008. Hurricane impacts on bottlenose dolphins in the northern Gulf of Mexico. *Gulf of Mexico Science* 25(1): 88-94.

Ross, G. J. B., 1971. Shark attack on an ailing dolphin *Stenella coeruleoalba* (Meyen). *South African Journal of Science* 67: 413-414.

Ross, G. J. B., and S. Leatherwood, 1994. Pygmy killer whale *Feresa attenuata* Gray, 1874. S. H. Ridgway and R. Harrison (eds), *Handbook of Marine Mammals, Volume 5: The first book of dolphins*. Academic Press: 387-404.

Rowntree, V., J. Darling, G. Silber, and M. Ferrari, 1980. Rare sighting of a right whale (*Eubalaena glacialis*) in Hawaii. *Canadian Journal of Zoology* 58: 4.

Sakamoto, W., K. Sato, H. Tanaka, and Y. Naito, 1993. Diving patterns and swimming environment of two loggerhead turtles during internesting. *Nippon Suisan Gakkaishi* 59(7):1129-1137.

Salden, D. R., 1989. An observation of apparent feeding by a sub-adult humpback whale off Maui, Hawaii. Abstract. Presented at the Eighth Biennial Conference on the Biology of Marine Mammals, Pacific Grove, CA. 7-11 December.

Salden, D. R., L. M. Herman, M. Yamaguchi, and F. Sato, 1999. Multiple visits of individual humpback whales (*Megaptera novaeangliae*) between the Hawaiian and Japanese winter grounds. *Canadian Journal of Zoology* 77: 504-508.

Salden, D., and J. Mickelsen, 1999. Rare sighting of a North Pacific right whale (*Eubalaena glacialis*) in Hawai‘i. *Pacific Science*, 53(4), 341-345.

Sale, A., P. Luschi, R. Mencacci, P. Lambardi, G. R. Hughes, G. C. Hays, and F. Papi, 2006. Long-term monitoring of leatherback turtle diving behaviour during oceanic movements. *Journal of Experimental Marine Biology and Ecology*, 328, 197-210. doi: 10.1016/j.jembe.2005.07.006.

Salmon, M., T. T. Jones, and K. W. Horch, 2004. Ontogeny of diving and feeding behavior in juvenile seaturtles: Leatherback seaturtles (*Dermochelys coriacea* L) and green seaturtles (*Chelonia mydas* L) in the Florida current. *Journal of Herpetology*, 38(1), 36-43.

Santos, M. B., V. Martin, M. Arbelo, A. Fernandez, and G. J. Pierce, 2007. Insights into the diet of beaked whales from the atypical mass strandings in the Canary Islands in September 2002. *Journal of the Marine Biological Association of the United Kingdom* 87: 243-251.

Sarti-Martinez, A. L., 2000. *Dermochelys coriacea*. In IUCN 2009. IUCN Red List of Threatened Species. Version 2009.2 Retrieved from www.iucnredlist.org, 19 November 2009.

Sarti-Martinez, L., S. A. Eckert, T. N. Garcia, and A. R. Barragan, 1996. Decline of the world’s largest nesting assemblage of leatherback turtles. *Marine Turtle Newsletter*, 74, 2-5. Retrieved from http://www.seaturtle.org/nmtn/archives/mtn74/mtn74p2.shtml.

Schilling, M. R., I. Seipt, M. T. Weinrich, S. E. Frohock, A. E. Kuhlberg, and P. J. Clapham, 1992. Behavior of individually identified sei whales *Balaenoptera borealis* during an episodic influx into the southern Gulf of Maine in 1986. *Fishery Bulletin* 90: 749-755.

Schlundt, C. E., J. J. Finneran, D. A. Carder, and S. H. Ridgway, 2000. Temporary shift in masked hearing thresholds of bottlenose dolphins, *Tursiops truncatus*, and white whales, *Delphinapterus leucas*, after exposure to intense tones. *Journal of the Acoustical Society of America*, 107(6), 3496-3508.

Schmelzer, I., 2000. Seals and seascapes: Covariation in Hawaiian monk seal subpopulations and the oceanic landscape of the Hawaiian Archipelago. *Journal of Biogeography* 27: 901-914.

Schofield, G., V. J. Hobson, M. K. S. Lilley, K. A. Katselidis, C. M. Bishop, P. Brown, and G. C. Hays, 2010. Inter-annual variability in the home range of breeding turtles: Implications for current and future conservation management. *Biological Conservation*, 143(3), 722-730. doi:10.1016/j.biocon.2009.12.011.

Schroeder, B. A., A. M. Foley, and D. A. Bagley, 2003. Nesting patterns, reproductive migrations, and adult foraging areas of loggerhead turtles. In A. B. Bolten and B. E. Witherington (eds), *Loggerhead Sea Turtles* (pp. 114-124). Washington, DC: Smithsonian Institution Press.

Scott, M. D., and S. J. Chivers, 1990. Distribution and herd structure of bottlenose dolphins in the eastern tropical Pacific Ocean. In S. Leatherwood and R. R. Reeves (eds), *The Bottlenose Dolphin*. Academic Press: 387-402.

Scott, Michael, and Susan Chivers, 2009. *Movements and Diving Behavior of Pelagic Spotted Dolphins*. Publications, Agencies and Staff of the U.S. Department of Commerce. Paper 46.

Sears, R., and W. F. Perrin, 2008. Blue whale. In W. F. Perrin, B. Wursig and J. G. M. Thewissen (eds), *Encyclopedia of Marine Mammals*. San Diego, CA, Academic Press: 120-124.

Sekiguchi, K., N. T. W. Klages, and P. B. Best, 1992. Comparative analysis of the diets of smaller odontocete cetaceans along the coast of southern Africa. *South African Journal of Marine Science* 12: 843-861.

Seminoff, J. A., and Marine Turtle Specialist Group Green Sea Turtle Task Force, 2004. *Marine Turtle Specialist Group Review: 2004 Global Status Assessment, Green Sea Turtle (*Chelonia mydas*).* pp. 71. The World Conservation Union (IUCN) Species Survival Commission, Red List Programme.

Seminoff, J. A., Nichols, W. J., Resendiz, A., and Brooks, L., 2003. Occurrence of hawksbill turtles, *Eretmochelys imbricata* (Reptilia: Cheloniidae), near the Baja California peninsula, Mexico. *Pacific Science*, 57(1), 9-16.

Seminoff, J. A., A. Resendiz-Hidalgo, T. W. Smith, and L. A. Yarnell, 2004. Diving patterns of green turtles in the Gulf of California, Mexico. In Coyne MS, C.R. (ed), *Proceedings of the Twenty-First Annual Symposium on Sea Turtle Biology and Conservation*. NOAA Technical Memorandum NMFS-SEFSC-528, pp. 321–323.

Setala, O., J. Norkko, and M. Lehtiniemi, 2016. Feeding type affects microplastic ingestion in a coastal invertebrate community. *Marine Pollution Bulletin* 102, 95-101.

Shallenberger, E. W., 1981. *The Status of Hawaiian Cetaceans*. Kailua, HI, Manta Corporation: 79.

Shane, S. H., 1990. Comparison of bottlenose dolphin behavior in Texas and Florida, with a critique of methods for studying dolphin behavior. In S. Leatherwood and R. R. Reeves (eds), *The Bottlenose Dolphin*. San Diego, CA, Academic Press: 541-558.

Shankar, K., J. Ramadevi, B. C. Choudhary, L. Singh, and R. K. Aggarwal, 2004. Phylogeography of olive ridley turtles (*Lepidochelys olivacea*) on the east coast of India: Implications for conservation theory. *Molecular Ecology*, 13 1899-1909. doi: 10.1111/j.1365-294X.2004.02195.x.

Širović, A., J. A. Hildebrand, S. M. Wiggins, M. A. McDonald, S. E. Moore, and D. Thiele, 2004. Seasonality of blue and fin whale calls and the influence of sea ice in the Western Antarctic Peninsula. *Deep-Sea Research II*. 51:2327-2344.

Skillman, R. A., and G. H. Balazs, 1992. Leatherback turtle captured by ingestion of squid bait on swordfish longline. *Fishery Bulletin*, 90, 807-808.

Skillman, R. A., and P. Kleiber, 1998. *Estimation of Sea Turtle Take and Mortality in the Hawai'i-Based Longline Fishery, 1994-96*. NOAA Technical Memorandum NMFS-SWFSC-257, pp. 52. U.S. Department of Commerce, NOAA, NMFS, Southwest Fisheries Science Center.

Smith, B. D., G. Braulik, S. Strindberg, R. Mansur, M. A. A. Diyan, and B. Ahmed, 2009. Habitat selection of freshwater-dependent cetaceans and the potential effects of declining freshwater flows and sea level rise in waterways of the Sundarbans mangrove forest, Bangladesh. *Aquatic Conservation: Marine and Freshwater Ecosystems* 19: 209-225.

Smith, M. E., A. S. Kane, and A. N. Popper, 2004. Noise-induced stress response and hearing loss in goldfish (*Carassius auratus*). *The Journal of Experimental Biology* 207, 427–435.

Smith, S. H., and D. E. Marx, Jr., 2016. De-facto marine protection from a Navy bombing range: Farallon De Medinilla, Mariana Archipelago, 1997 to 2012. *Marine Pollution Bulletin, 102*(1), 187–198. doi: 10.1016/j.marpolbul.2015.07.023.

Smultea, M. A., 1994. Segregation by humpback whale (*Megaptera novaeangliae*) cows with a calf in coastal habitat near the island of Hawaii. *Canadian Journal of Zoology* 72: 805-811.

Smultea, M. A., J. L. Hopkins, and A. M. Zoidis, 2007. *Marine Mammal Visual Survey in and near the Alenuihaha Channel and the Island of Hawai'i: Monitoring in Support of Navy Training Exercises in the Hawai'i Range Complex, January 27 – February 2, 2007.* Oakland, CA: 63.

Smultea, M. A., J. L. Hopkins, and A. M. Zoidis, 2008. *Marine Mammal and Sea Turtle Monitoring Survey in Support of Navy Training Exercises in the Hawai'i Range Complex November 11-17, 2007*. C. R. Organization. Oakland, CA: 62.

Smultea, M. A., T. A. Jefferson, and A. M. Zoidis, 2010. Rare sightings of a Bryde's whale (Balaenoptera edeni) and sei whales (*B. borealis*) (Cetacea: Balaenopteridae) northeast of O'ahu, Hawai'i. *Pacific Science* 64: 449-457.

Soma, M., 1985. Radio biotelemetry system applied to migratory study of turtle. *Journal of the Faculty of Marine Science and Technology*, 21, 47-56.

Southall, B. L., A. E. Bowles, W. T. Ellison, J. J. Finneran, R. L. Gentry, C. R. Greene, Jr., D. Kastak, D. R. Ketten, J. H. Miller, P. E. Nachtigall, W. J. Richardson, J. A. Thomas, P. L. Tyack, 2007. Marine mammal noise exposure criteria: Initial scientific recommendations. *Aquatic Mammals* 33:411-521.

Southall, B., J. Calambokidis, P. Tyack, D. Moretti, J. Hildebrand, C. Kyburg, R. Carlson, A. S. Friedlaender, E. A. Falcone, G. S. Schorr, A. Douglas, S. L. Deruiter, J. A. Goldbogen, and J. Barlow, 2011. *Biological and Behavioral Response Studies of Marine Mammals in Southern California, 2010 ("SOCAL-10") SOCAL-BRS.* Project Report. pp. 29.

Southall, B., J. Calambokidis, P. Tyack, D. Moretti, A. Friedlaender, S. DeRuiter, J. Goldbogen, E. Falcone, G. Schorr, A. Douglas, A. Stimpert, J. Hildebrand, C. Kyburg, R. Carlson, T. Yack, and J. Barlow, 2012. *Biological and Behavioral Response Studies of Marine Mammals in Southern California, 2011 ("SOCAL-11").* Final Project Report, 8 March 2012. Manuscript on file.

Southall, B. L., P. L. Tyack, D. Moretti, C. Clark, D. Claridge, and I. Boyd, 2009. Behavioral responses of beaked whales and other cetaceans to controlled exposures of simulated sonar and other sounds. *18th Biennial Conference on the Biology of Marine Mammals*. Quebec City, Quebec, Canada.

Southwood, A. L., R. D. Andrews, M. E. Lutcavage, F. V. Paladino, N. H. West, R. H. George, and D. R. Jones, 1999. Heart rates and diving behavior of leatherback sea turtles in the eastern Pacific Ocean. *Journal of Experimental Biology*, 202, 1115-1125.

Spotila, J. R., A. E. Dunham, A. J. Leslie, A. C. Steyermark, P. T. Plotkin, and F. V. Paladino, 1996. Worldwide population decline of *Dermochelys coriacea*: Are leatherback turtles going extinct? *Chelonian Conservation and Biology*, 2(2), 209-222.

Spotila, J. R., R. D. Reina, A. C. Steyermark, P. T. Plotkin, and F. V. Paladino, 2000. Pacific leatherback turtles face extinction. *Nature*, 405, 529-530.

Stadler, J. H., and D. P. Woodbury, 2009. Assessing the effects of fishes from pile driving: Application of new hydroacoustic criteria. *Inter-Noise 2009*, Ottawa, Canada. August 23-26, 2009.

Stafford, K., D. Bohnenstiehl, M. Tolstoy, E. Chapp, D. Mellinger, and S. Moore, 2004. Antarctic-type blue whale calls recorded at low latitudes in the Indian and eastern Pacific oceans. *Deep-Sea Research I* 51: 1337-1346.

Stancyk, S. E., 1982. Non-human predators of sea turtles and their control. In K. A. Bjorndal (ed), *Biology and Conservation of Sea Turtles* (pp. 139-152). Washington, DC: Smithsonian Institution Press.

Starbird, C. H., A. Baldridge, and J. T. Harvey, 1993. Seasonal occurrence of leatherback sea turtles (*Dermochelys coriacea*) in the Monterey Bay region, with notes on other sea turtles, 1986-1991. *California Fish and Game*, 79(2), 54-62.

State of Hawaii, 2015. County Economic Conditions: 4th Quarter 2015. Department of Business, Economic Development & Tourism. Accessed online at http://dbedt.hawaii.gov/economic/qser/county on January 12, 2016.

State of Hawaii Department of Transportation Harbors Division (HI DOT), 2001. *Kauai Commercial Harbors 2025 Master Plan*. September 2001.

Steiger, G., J. Calambokidis, J. Straley, L. Herman, S. Cerchio, D. Salden, J. Urban-R, J. Jacobsen, O. Ziegesar, K. Balcomb, C. Gabriele, M. Dahlheim, S. Uchida, J. Ford, P. Ladron de Guevara-P, M. Yamaguchi, and J. Barlow, 2008. Geographic variation in killer whale attacks on humpback whales in the North Pacific: implications for predation pressure. *Endangered Species Research* 4(3): 247- 256.

Stewart, B. S., G. A. Antonelis, J. D. Baker, and P. K. Yochem, 2006. Foraging biogeography of Hawaiian monk seals in the Northwestern Hawaiian Islands. *Atoll Research Bulletin* 543: 131–146.

Storch, S., R. P. Wilson, Z. M. Hillis-Starr, and D. Adelung, 2005. Cold-blooded divers: temperature dependent dive performance in the wild hawksbill turtle *Eretmochelys imbricata*. *Marine Ecology Progress Series*, 293, 263-271.

Suarez, A., P. H. Dutton, and J. Bakarbessy, 2000. Leatherback (*Dermochelys coriacea*) nesting on the north Vogelkop coast of Irian Jaya, Indonesia. In H. Kalb and T. Wibbels (eds), *Proceedings of the Nineteenth Annual Symposium on Sea Turtle Biology and Conservation.* Abstract. NOAA Technical Memorandum NMFS-SEFSC-443, pp. 260. U.S. Department of Commerce, NOAA, NMFS.

Swisdak, Jr., M. M., 1978. Explosion Effects and Properties: Part II - Explosion Effects in Water. Naval Surface Weapons Center, Silver Spring, Maryland. NSWC/WOL TR 76-116.

Thompson, P.M., D. Lusseau, T. Barton, D. Simmons, J. Rusin, and H. Bailey, 2010. Assessing the responses of coastal cetaceans to the construction of offshore wind turbines. *Marine Pollution Bulletin* 60:1200-1208.

Turtle Expert Working Group, 2007. *An Assessment of the Leatherback Turtle Population in the Atlantic Ocean*. NOAA Technical Memorandum NMFS-SEFSC-555, pp. 116, U.S. Department of Commerce, NOAA, NMFS, Southeast Fisheries Science Center.

Twiss, J. R., Jr., and R. R. Reeves, 1999. *Conservation and Management of Marine Mammals*. Washington, D.C., Smithsonian Institution Press: 471.

Tyack, P. L., 2009a. Human-generated sound and marine mammals. *Physics Today*: 39-44.

Tyack, P. L., 2009b. Acoustic playback experiments to study behavioral responses of free-ranging marine animals to anthropogenic sound. *Marine Ecology Progress Series*, 395, 13. 10.3354/meps08363.

Tyack, P., W. Zimmer, D. Moretti, B. Southall, D. Claridge, J. Durban, and I. Boyd, 2011. *Beaked Whales Respond to Simulated and Actual Navy Sonar*. Electronic version. PLoS ONE, 6(3), 15. 10.1371/journal.pone.0017009.

United Nations Educational, Scientific and Cultural Organization (UNESCO), 2016. World Heritage List: Papahānaumokuākea. Accessed online at http://whc.unesco.org/en/list/1326 on May 20, 2016.

United Nations Framework Convention on Climate Change, 2000. Guidelines for the Preparation of National Communications by Parties Included In Annex I to the Convention, Part I: UNFCCC Reporting Guidelines on Annual Inventories (Following Incorporation of the Provisions of Decision 13/CP.9). FCCC/SBSTA/2004/8.

United Nations Framework Convention on Climate Change, 2004. Guidelines for the Preparation of National Communications by Parties Included in Annex I to the Convention, Part I: UNFCCC Reporting Guidelines on Annual Inventories (following incorporation of the provisions of decision 13/CP.9). (FCCC/SBSTA/2004/8).

United States Army Center for Health Promotion and Preventive Medicine (USACHPPM), 2005. Operational Noise Manual: An Orientation for Department of Defense Facilities. November.

University of Hawaii, 2016. Kauai FADS Buoy Map. Accessed online at http://www.hawaii.edu/HIMB/FADS/Maps%20&%20Loc/KauaiMap.html on January 25, 2016.

U.S. Army, 1975. *Noise Hazard Evaluation, Sound Level Data of Noise Sources*. U.S. Army Environmental Hygiene Agency. Aberdeen Proving Ground, Maryland.

U.S. Commission on Ocean Policy, 2004. *An Ocean Blueprint for the 21st Century*. Final Report. Washington, DC 2004. ISBN#0–9759462–0–X.

U.S. Environmental Protection Agency (USEPA), 1974. *Information on Levels of Environmental Noise Requisite to Protect the Public Health and Welfare with an Adequate Margin of Safety*. USEPA Report 550/9/74/004. March.

U.S. Environmental Protection Agency, 1992. *Procedures for Emission Inventory Preparation*. Vol. IV: Mobile Sources, pp. 240. Accessed online at https://www3.epa.gov/otaq/models/nonrdmdl/r92009.pdf on March 3, 2016.

U.S. Environmental Protection Agency (USEPA), 2009b. *Endangerment and Cause or Contribute Findings for Greenhouse Gases Under Section 202(a) of the Clean Air Act*.

U.S. Environmental Protection Agency (USEPA), 2009c. *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2007*.

U.S. Environmental Protection Agency (USEPA), 2009d. *Technical Support Document for Endangerment and Cause or Contribute Findings for Greenhouse Gases Under Section 202(a) of the Clean Air Act*.

U.S. Environmental Protection Agency (USEPA), 2015a. *Criteria Pollutant Nonattainment Area Summary Report*. Accessed online at http://www3.epa.gov/airquality/greenbook/ancl3.html on January 18, 2016.

U.S. Environmental Protection Agency (USEPA), 2015b. The National Emissions Inventory 2011 Version 2b. Retrieved from http://www.epa.gov/air-emissions-inventories/2011-national-emissions-inventory-nei-data on January 18, 2015.

U.S. Environmental Protection Agency (USEPA), 2016. Hazardous Air Pollutants. Retrieved from http://www.epa.gov/haps, February 2, 2016.

U.S. Navy, 2001. *Final Environmental Impact Statement (EIS)/Overseas Environmental Impact Statement (OEIS) for the Shock Trial of the USS WINSTON S. CHURCHILL (DDG 81)*. U.S. Department of the Navy: Washington, DC.

U.S. Navy, 2002. *Rim of the Pacific (RIMPAC) Programmatic Environmental Assessment.*

U.S. Navy, 2005. *Marine Resources Assessment for the Hawaiian Islands Operating Area*. Final Report. Naval Facilities Engineering Command. Pearl Harbor, HI.

UXOINFO, 2013. Policies, Regulations, and Laws. Information accessed on the internet at http://www.uxoinfo.com/uxoinfo/policy2.cfm. Information accessed on January 8, 2013.

Van Dam, R. P., and C. E. Diez, 1996. Diving behavior of immature hawksbills (*Eretmochelys imbricata*) in a Caribbean cliff-wall habitat. *Marine Biology*, 127, 171-178.

Van Dam, R. P., and C. E. Diez, 1997. Diving behavior of immature hawksbill turtles (*Eretmochelys imbricata*) in a Caribbean reef habitat. *Coral reefs* (1997) 16:133-138.

Van Waerebeek, K., F. Felix, B. Haase, D. Palacios, D. M. Mora-Pinto, and M. Munoz-Hincapie, 1998. Inshore records of the striped dolphin, *Stenella coeruleoalba*, from the Pacific coast of South America. *Reports of the International Whaling Commission* 48: 525-532.

Wade, P. R., 1994. Abundance and Population Dynamics of Two Eastern Pacific Dolphins, *Stenella attenuata* and *Stenella longirostris orientalis*. Doctoral dissertation. University of California, San Diego.

Wade, P. R., and T. Gerrodette, 1993. Estimates of cetacean abundance and distribution in the eastern tropical Pacific. *Reports of the International Whaling Commission* 43: 477-493.

Wade, P. R., J. M. Ver Hoef, and D. P. DeMaster, 2009. Mammal-eating killer whales and their prey — trend data for pinnipeds and sea otters in the North Pacific Ocean do not support the sequential megafaunal collapse hypothesis. *Marine Mammal Science* 25(3): 737-747.

Walker, S. W., C. L. Osburn, T. J. Boyd, L. J. Hamdan, R. B. Coffin, M. T. Montgomery, J. P. Smith, Q. X. Li, C. Hennessee, F. Monteil, and J. Hawari, 2006. Mineralization of 2,4,6-Trinitrotoluene (TNT) in Coastal Waters and Sediments. Naval Research Laboratory NRL/FR/6114-06-10, 135. August 21, 2006.

Wallace, B. P., R. L. Lewison, S. L. McDonald, R. K. McDonald, C. Y. Kot, S. Kelez, and L. B. Crowder, 2010. Global patterns of marine turtle bycatch. *Conservation Letters*, 3(3), 131-142. doi: 10.1111/j.1755-263X.2010.00105.x.

Walsh, Michael R., 2007. *Explosives Residues Resulting from the Detonation of Common Military Munitions: 2002-2006*. Final Report. U.S. Army Corps of Engineers ERDC/CRREL TR-07-2. February 2007.

Wang, J. Y., and S. C. Yang, 2006. Unusual cetacean stranding events of Taiwan in 2004 and 2005. *Journal of Cetacean Research and Management* 8(3): 283-292.

Wang, J. Y., S. C. Yang, and H. C. Liao, 2001. Species composition, distribution and relative abundance of cetaceans in the waters of southern Taiwan: Implications for conservation and eco-tourism. *Journal of the National Parks of Taiwan* 11(2): 136-158.

Waring, G. T., T. Hamazaki, D. Sheehan, G. Wood, and S. Baker, 2001. Characterization of beaked whale (Ziphiidae) and sperm whale (*Physeter macrocephalus*) summer habitat in shelf-edge and deeper waters off the northeast U.S. *Marine Mammal Science* 17(4): 703-717.

Watkins, W. A., M. A. Daher, G. M. Reppucci, J. E. George, D. L. Martin, N. A. DiMarzio, and D. P. Gannon, 2000. Seasonality and distribution of whale calls in the North Pacific. *Oceanography* 13(1): 62-67.

Watwood, S.L., and D.M. Buonantony, 2012. *Dive Distribution and Group Size Parameters for Marine Species Occurring in Navy Training and Testing Areas in the North Atlantic and North Pacific Oceans*. NUWC-NPT Technical Document 12,085. 12 March 2012.

Weller, D. W., 2008. Predation on marine mammals. In W. F. Perrin, B. Würsig, and J. G. M. Thewissen (eds), *Encyclopedia of Marine Mammals*. San Diego, CA, Academic Press: 923-931.

Weller, D. W., B. Wursig, H. Whitehead, J. C. Norris, S. K. Lynn, R. W. Davis, N. Clauss and P. Brown, 1996. Observations of an interaction between sperm whales and short-finned pilot whales in the Gulf of Mexico. *Marine Mammal Science* 12(4): 588-593.

Wells, R. S., J. B. Allen, S. Hofmann, D. A. Fauquier, and M. D. Scott, 2008. Consequences of injuries on survival and reproduction of common bottlenose dolphins (*Tursiops truncatus*) along the west coast of Florida. *Marine Mammal Science* 24(4): 774-794.

Wells, R. S., and M. D. Scott, 1999. Bottlenose dolphin *Tursiops truncatus* (Montagu, 1821). In S. H. Ridgway and R. Harrison (eds), *Handbook of Marine Mammals, Volume 6: The Second Book of Dolphins and the Porpoises*. San Diego, CA, Academic Press: 137-182.

Wells, R. S., C. A. Manire, L. Byrd, D. R. Smith, J. G. Gannon, D. Fauqiuer, and K. D. Mullin, 2009. Movements and dive patterns of a rehabilitated Risso's dolphin, *Grampus griseus*, in the Gulf of Mexico and Atlantic Ocean. *Marine Mammal Science* 25(2): 420-429.

Wells, R. S., and M. D. Scott, 2008. Common bottlenose dolphin *Tursiops truncatus*. In W. F. Perrin, W. B. and J. G. M. Thewissen (eds), *Encyclopedia of Marine Mammals*. Academic Press: 249-255.

Werth, A. J., 2006a. Mandibular and dental variation and the evolution of suction feeding in Odontoceti. *Journal of Mammalogy* 87(3): 579-588.

Werth, A. J., 2006b. Odontocete suction feeding: Experimental analysis of water flow and head shape. *Journal of Morphology* 267: 1415-1428.

West, K. L., S. Sanchez, D. Rotstein, K. M. Robertson, S. Dennison, G. Levine, B. Jensen, 2012. A Longman's beaked whale (*Indopacetus pacificus*) strands in Maui, Hawaii, with first case of morbillivirus in the central Pacific. *Marine Mammal Science*, n/a-n/a. 10.1111/j.1748-7692.2012.00616.x. Retrieved from http://dx.doi.org/10.1111/j.1748-7692.2012.00616.x.

West, K. L., W. A. Walker, R. W. Baird, W. White, G. Levine, E. Brown, and D. Schofield, 2009. Diet of pygmy sperm whales (*Kogia breviceps*) in the Hawiian Archipelago. *Marine Mammal Science* 25(4): 931-943.

Western Pacific Regional Fishery Management Council (WPRFMC), 2009a. *Fishery Ecosystem Plan for the Hawaii Archipelago*. September 4, 2009.

Western Pacific Regional Fishery Management Council (WPRFMC), 2009b. *Fishery Ecosystem Plan for Pacific Pelagic Fisheries of the Western Pacific Region*. September 24, 2009.

Western Regional Climate Center, 2010. Hawaii climate. Retrieved from http://www.wrcc.dri.edu/narratives/HAWAII.htm, accessed on February 10, 2016.

Whitehead, H., 2003. *Sperm Whales: Social Evolution in the Ocean*. University of Chicago Press: 431.

Whitehead, H., A. Coakes, N. Jaquet, and S. Lusseau, 2008. Movements of sperm whales in the tropical Pacific. *Marine Ecology Progress Series* 361: 291-300.

Wilson, J. V, S. A. Jenkins, J. Wasyl, A. DeVisser, and B. Sugiyama, 2008. *Predicting the Mobility and Burial of Underwater Unexploded Ordnance (UXO) Using the UXO Mobility Model*. ESTCP Project MM-0417.

Witherington, B., and S. Hirama, 2006. Sea turtles of the epi-pelagic Sargassum drift community. In M. Frick, A. Panagopoulou, A. F. Rees, and K. Williams (eds), *Book of Abstracts. Twenty-Sixth Annual Symposium on Sea Turtle Biology and Conservation.* Abstract, pp. 209. Athens, Greece: International Sea Turtle Society.

Witt, M. J., L. A. Hawkes, M. H. Godfrey, B. J. Godley, and A. C. Broderick, 2010. Predicting the impacts of climate change on a globally distributed species: the case of the loggerhead turtle. *Journal of Experimental Biology*, 213(6), 901-911. doi: 10.1242/jeb.038133.

Witzell, W. N., 1983. *Synopsis of Biological Data on the Hawksbill Turtle* Eretmochelys imbricata *(Linnaeus, 1766).* FAO Fisheries Synopsis 137, pp. 78. Rome, Italy: Food and Agriculture Organization of the United Nations.

Wood, F., and J. Wood, 1993. Release and recapture of captive-reared green sea turtles, *Chelonia mydas*, in the waters surrounding the Cayman Islands. *Herpetological Journal* 3:84-89.

Wright, D. G., 1982. A Discussion Paper on the Effects of Explosives on Fish and Marine Mammals in the Waters of the Northwest Territories Canadian Technical Report of Fisheries and Aquatic Sciences. pp. 1-16. Winnipeg, Manitoba: Western Region Department of Fisheries and Oceans.

Würsig, B., and W. J. Richardson, 2009. Noise, effects of. Pp. 765–772. In Perrin, W.F., Würsig, B., and J.G.M. Thewissen (eds), *The Encyclopedia of Marine Mammals*, Ed. 2. Academic/Elsevier Press, San Diego, Ca. 1316 pp.

Wysocki, L. E., J. P. Dittami, and F. Ladich, 2006. Ship noise and cortisol secretion in European freshwater fishes. *Biological Conservation* 128 (2006), pp 501–508.

Yamada, T. K., 1997. Strandings of cetacea to the coasts of the Sea of Japan - with special reference to Mesoplodon stejnegeri. IBI Reports 7: 9-20.0

Yelverton, J. T., D. R. Richmond, E. R. Fletcher, and R. K. Jones, 1973. Safe Distances from Underwater Explosions for Mammals and Birds. Lovelace Foundation for Medical Education and Research, Albuquerque, New Mexico. pp. 66.

Yelverton, J. T., and D. R. Richmond, 1981. Underwater explosion damage risk criteria for fish, birds, and mammals. *102nd Meeting of the Acoustical Society of America Journal of the Acoustical Society of America*, Miami Beach, Florida. pp. S84.

Yelverton J. T., D. R. Richmond, W. Hicks, K. Saunders, E. R. Fletcher, 1975. The relationship between fish size and their response to underwater blast. In Defense Nuclear Agency (ed), Lovelace Foundation for Medical Education and Research, Washington, D.C. pp. 40.

Young, G. A., 1991. *Concise Methods for Predicting the Effects of Underwater Explosions on Marine Life*. Naval Surface Weapons Center, Research and Technology Department, Dahlgren, Virginia. July 1, 1991.

Yudhana, A., J. Din, A. S. Sundari, and R. B. R. Hassan, 2010. Green turtle hearing identification based on frequency spectral analysis. *Applied Physics Research* 2, 125-134.

Zug, G. R., and J. F. Parham, 1996. Age and growth in leatherback turtles *Dermochelys coriacea* (Testudines: Dermochelyidae): a skeletochronological analysis. *Chelonian Conservation and Biology*, 2(2), 244-249.

Zug, G. R., Chaloupka, M., and Balazs, G. H., 2006. Age and growth in olive ridley sea turtles (*Lepidochelys olivacea*) from the north-central Pacific: a skeletochronological analysis. *Marine Ecology*, 27, 263-270. doi: 10.1111/j.1439-0485.2006.00109.x.

This page is intentionally blank.

APPENDIX A

AGENCY CORRESPONDENCE AND CONSULTATION

This page is intentionally blank.

Cooperating Agency Request to Navy Pacific Fleet

30 March 2016

HQ ACC/A4C
130 Douglas Street
Joint Base Langley-Eustis, VA 23665

Commander, U.S. Pacific Fleet
Attn: Mr. Larry Foster, Director, Environmental Readiness Division, N465
250 Makalapa Drive
Pearl Harbor, HI 96869-3131

The Air Force is intitiating an Environmental Assessment/Overseas Environmental Assessment (EA/OEA) to evaluate the impacts of conducting operational evaluations with long range strike munitions. Missions are planned to begin in summer 2016 and continue for the following five years. Tests are proposed to occur at the Barking Sands Underwater Range Expansion (BSURE) area of the Pacific Missile Range Facility (PMRF). The Air Force would like to request that the U.S. Pacific Fleet formally participate as a Cooperating Agency in the preparation of the EA/OEA, as prescribed in the President's Council on Environmental Quality (CEQ) National Environmental Policy Act (NEPA) Regulations, 40 CFR Part 1501.6, *Cooperating Agencies*.

The Air Force asks for your participation as a cooperating agency in preparation of the EA/OEA as generally outlined in the steps below. To address the specific responsibilities of the Air Force as Lead Agency and U.S. Pacific Fleet as Cooperating Agency, we request support with the following in completion of the EA/OEA:

(1) Sharing of baseline data and information to support the EA/OEA analysis;

(2) Reviewing the EA to ensure consistency and accuracy with ongoing Pacific Fleet missions;

(3) Making staff support available to enhance interdisciplinary review capability, and correspondence; and

(4) Responding in writing to this request.

The Air Force requires the support of cooperating agencies be timely, to avoid unnecssary delays in the NEPA process. Should you or your staff have further questions regarding this memo, our point of contact is Mr. Mike Ackerman, Air Force Civil Engineer Center NEPA Division, at (210) 925-2741 or michael.ackerman.2@us.af.mil.

JENNIFER L. KILBOURN, Colonel, USAF
Chief, Civil Engineer Division

cc:
HQ USAF/A4CI
AFLOA/JACE (ACC)

SHPO Consultation Letter

DEPARTMENT OF THE AIR FORCE
AIR FORCE CIVIL ENGINEER CENTER
JOINT BASE SAN ANTONIO LACKLAND TEXAS

AFCEC/CZN
2261 Hughes Ave., Ste. 155
JBSA Lackland, TX 78236-9853

MAR 30 2016

Dr. Alan Downer
Hawaii State Historic Preservation Division
Kakuhihewa Building, Suite 555
601 Kamokila Boulevard
Kapolei, HI 96707

RE: Section 106 Consultation for the Proposed Long Range Strike Weapon System Evaluation Program in the Barking Sands Underwater Range Expansion Area of the Pacific Missile Range Facility, Hawaii

Dear Dr. Downer,

In accordance with Section 106 of the National Historic Preservation Act and its implementing regulations, 36 CFR Part 800, the U.S Air Force (USAF) is providing information for your review and concurrence regarding the above-referenced project.

The USAF Long Range Strike Weapon System Evaluation Program proposes to utilize the open ocean areas located in the Barking Sands Underwater Range Expansion (BSURE) area of the Pacific Missile Range Facility (PMRF) for operational evaluations of munitions. The PMRF is located in Hawaii on and off the western shores of the island of Kauai and includes broad ocean areas to the north, south, and west (Attachment 1 and 2). Activities to be conducted involve the USAF conducting operational evaluations of long range strike weapons and other munitions at the northern portion of the BSURE area. Operations would be conducted in accordance with currently approved aircraft and weapons standard procedures and instructions at the PMRF. Activities specific to the Long Range Strike WSEP operational evaluations would consist of releasing live and inert munitions in military controlled airspace. All live releases would result in airbursts, surface, or subsurface (3 meters below surface) detonations. The current proposed timeframe for this testing is 2016 through 2021 with a maximum annual expenditure of 114 munitions. No near-shore or land-based operations or construction activities would take place as part of this mission.

The Area of Potential Effect (APE) for this project is equivalent to the project biological species impact footprint set forth in the Long Range Strike Weapon System Evaluation Program EA currently being developed. This footprint is a two nautical mile radius around the target area, in the open ocean area within the BSURE range as detailed on Attachment 3. The seafloor depth underneath the target area is 4,645 meters (15,240 feet).

The shipwreck database maintained by the National Oceanic and Atmospheric Administration Office of Coast Survey Advanced Wreck and Obstruction Information System (AWOIS), was queried for information regarding submerged shipwrecks and obstructions in and around the PMRF. In addition, previous environmental documents, such as the Hawaii-Southern California Training and Testing Final Environmental Impact Statement/Overseas Environmental Impact Statement (2013), and other written and online documents were reviewed as a baseline for previous research. The National Register Information System and Hawaii SHPO online resources were also reviewed for any relevant information.

Based on the following information, the USAF has determined that the proposed activities within the BSURE area of the PMRF would result in a "no historic properties affected" determination in accordance with Section 106 implementing regulations under 36 CFR 800.4(d)(1).

1) Due to the distance offshore of the Proposed Action (44 NM), the primary cultural resource concern would be shipwrecks. There are a number of known wrecks and obstructions in the region; however none of these are within the APE for the Proposed Action. The nearest known wreck is located 4 NM northeast of the impact location and 1 NM outside the northern boundary of the BSURE range (Attachment 3). The APE contains no submerged sites eligible for or listed on the NRHP. The only submerged NRHP-eligible sites in Hawaii are located at Pearl Harbor, outside of the APE. The Papahanaumokuakea Marine National Monument is the nearest World Heritage Site but is also outside of the APE for the Proposed Action.

2) These proposed activities are similar to those historically conducted for some time with no cultural resources being affected throughout the years. Explosive exercises have historically taken place on this range within the open ocean, away from where there are any identified cultural or historical resources. Therefore, proposed activities are consistent with those activities currently conducted in this area.

Attached for your review are maps showing the regional location of the undertaking, the range being utilized, identified shipwreck and obstructions, and the target location supporting our finding. This documentation helps satisfy requirements set forth at §800.11(d).

As defined in 36 CFR §800.4(d)(1)(i) we will assume State Historic Preservation Division concurrence if no response is received from your office within 30 days of receipt of this letter.

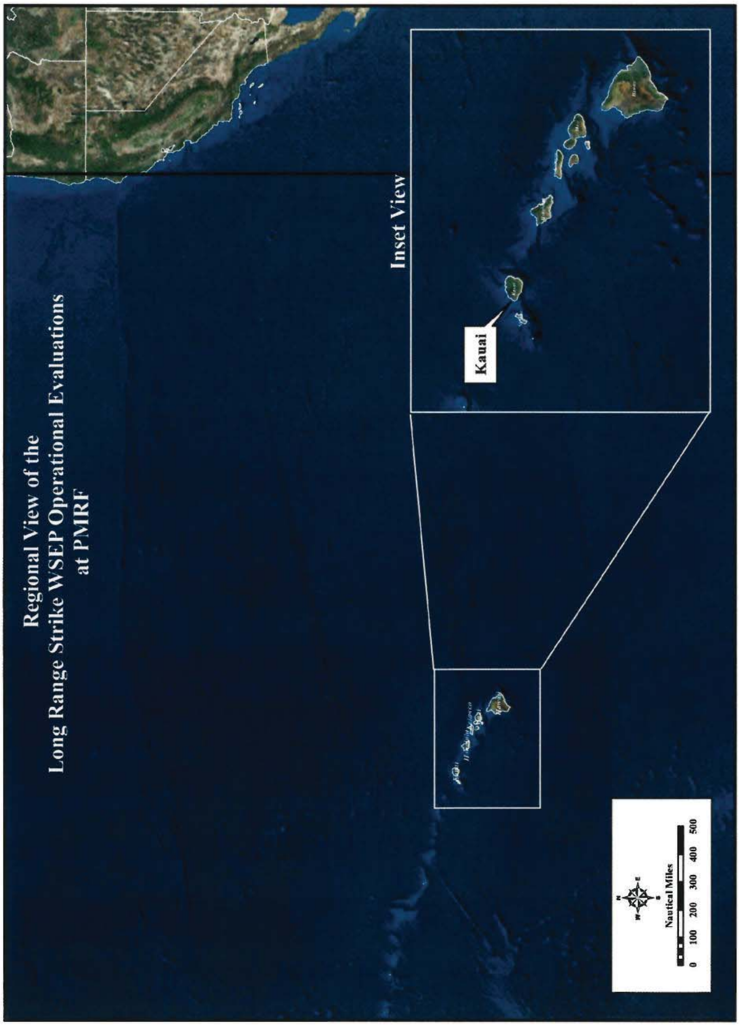
Should you have any questions regarding the undertaking, please contact Mike Ackerman at 1-(210) 925-2741 or at michael.ackerman.2@us.af.mil.

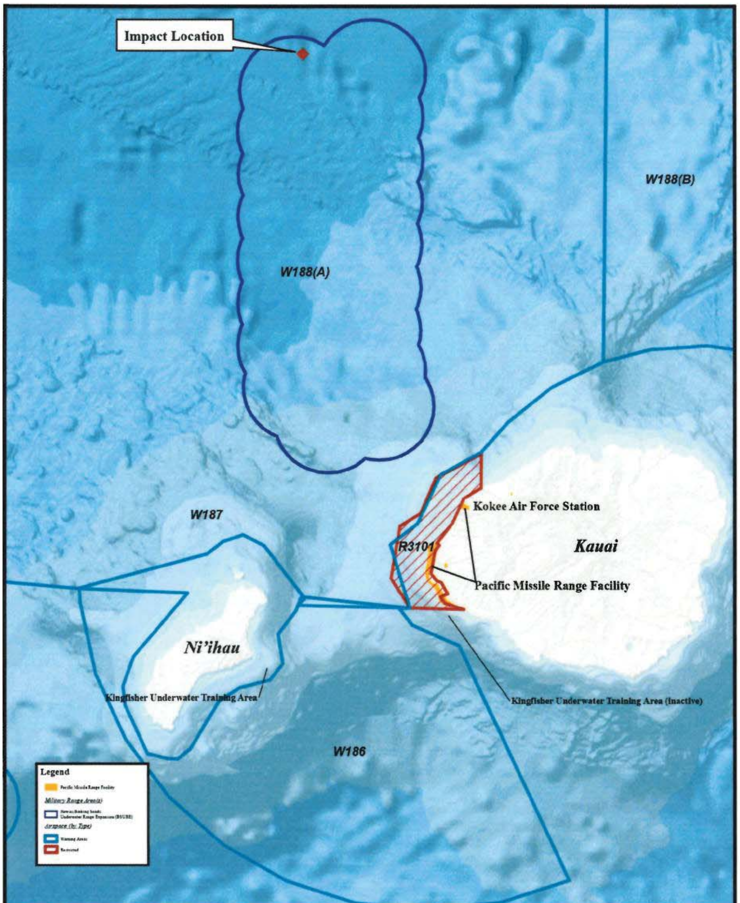
Sincerely,

Michael J Ackerman

Michael Ackerman
Program Manager
NEPA Division (AFCEC/CZN)

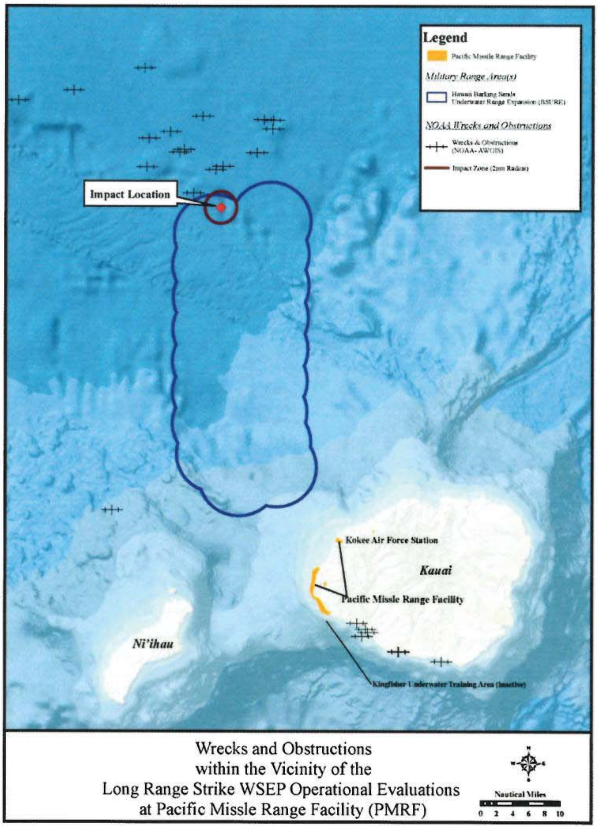
Enclosures:
1. Regional View of Long Range Strike WSEP Operational Evaluations
2. Figure of the BSURE Area
3. Shipwreck Locations near PMRF


Regional View of the
Long Range Strike WSEP Operational Evaluations
at PMRF
Inset View
Kauai
Nautical Miles
0 100 200 300 400 500



Ranges and Training Areas
within the Vicinity of the
Long Range Strike WSEP Operational Evaluations
at Pacific Missile Range Facility (PMRF)

Nautical Miles
0 2 4 6 8 10



Wrecks and Obstructions
within the Vicinity of the
Long Range Strike WSEP Operational Evaluations
at Pacific Missle Range Facility (PMRF)

April 20, 2016

IN REPLY REFER TO:
LOG NO: 2016.00803
DOC NO: 1604MN10
Archaeology

Michael Ackerman
Department of the Air Force
Air Force Civil Engineer Center
Via email: michael.ackerman.2@us.af.mil

Dear Mr. Ackerman:

SUBJECT: **National Historic Preservation Act (NHPA) Section 106 Review –
Proposed Long Range Strike Weapon System Evaluation
Waimea Ahupuaʻa, Kona District, Island of Kauaʻi
TMK: (4) 1-2-002:013**

On April 4, 2016, the SHPD received a request from the United States Air Force (USAF) for the State Historic Preservation Officer's (SHPO) concurrence with a "no historic properties affected" determination for the proposed Long Range Strike Weapon System Evaluation undertaking planned within the Barking Sands Underwater Range Expansion (BSURE) area of the Pacific Missile Range Facility (PMRF). PMRF is located west of Kekaha, Kauaʻi. The lead agency is the U.S. Air Force and the landowner at PMRF is the United States (U.S.) government. The project is considered an undertaking, pursuant to 36CFR§800.3.

The USAF has defined the Area of Potential Effect (APE) as equivalent to the project biological species impact footprint proposed in the Environmental Assessment (EA), an open ocean area off the coast of Kauaʻi and Niihau with a radius of two nautical miles, including a depth to the ocean floor, at 4,645 meters. The current proposed timeframe for the testing is from 2016 through 2021, with a maximum annual expenditure of 114 munitions. The project will consist of releasing live and inert munitions into military controlled airspace. All live releases will result in airbursts, surface, or subsurface detonation. No near-shore or land-based operations or construction activities are included in the project proposal.

The USAF consulted the National Oceanic and Atmospheric Administration (NOAA)'s Office of Coast Survey Advanced Wreck and Obstruction Information System (AWOIS) to determine potential effects on identified shipwrecks, and has provided a graphic showing the proposed impact site and the APE. All identified shipwrecks are outside of the APE. SHPD confirmed this information with NOAA Maritime Heritage Coordinator Hans Van Tilberg.

The SHPO concurs with the USAF's determination of **no historic properties affected** for this undertaking.

The USAF is the office of record for this undertaking. Please maintain a copy of this letter with you environmental review record for this undertaking. Please reference our project number in any communication with this office regarding this understanding.

Please contact Mary Jane Naone, Kauai Lead Archaeologist, at maryjane.naone@hawaii.gov or at (808) 271-4940 (Oʻahu number) regarding any changes in project scope, APE, or for any questions regarding historic properties concerns.

Mahalo for your cooperation in preserving and protecting significant historic and cultural properties.

Aloha,

Alan S. Downer, Ph.D.
Administrator, State Historic Preservation Division
Deputy Historic Preservation Officer

cc: Hans Van Tilburg, Maritime Heritage Coordinator, NOAA Office of Marine Sanctuaries

Long Range Strike WSEP EFH Assessment with Cover Letter

DEPARTMENT OF THE AIR FORCE
AIR FORCE CIVIL ENGINEER CENTER
JOINT BASE SAN ANTONIO LACKLAND TEXAS

AFCEC/CZN
2261 Hughes Ave., Ste. 155
JBSA Lackland, TX 78236-9853

19 April, 2016

Mr. Gerry Davis
Assistant Regional Administrator, Habitat Conservation Division
Pacific Islands Regional Office
National Marine Fisheries Service
1601 Kapiolani Blvd, Suite 1110
Honolulu, HI 96814-4700

SUBJECT: Submission of the Essential Fish Habitat Assessment for the Long Range Strike Weapon Systems Evaluation Program

Dear Mr. Davis,

This letter and attached document is being submitted to the National Marine Fisheries Service to fulfill requirements under the Magnuson-Stevens Fishery Conservation and Management Act for activities described under the Preferred Alternative in the Long Range Strike Weapon Systems Evaluation Program (WSEP) Environmental Assessment/Overseas Environmental Assessment (EA/OEA). The Essential Fish Habitat Assessment analyzes potential impacts to essential fish habitat and federally managed fisheries that may occur within the Long Range Strike WSEP mission area.

The Proposed Action would authorize the 86th Fighter Weapons Squadron to conduct operational evaluations of long range strike weapons and other munitions at the Pacific Missile Range Facility, offshore of Kauai, Hawaii. Live (explosive) and inert (non-explosive) munitions would be released from multiple types of aircraft, including bombers and fighter aircraft, within military controlled airspace over the Pacific Ocean. The weapon impact point is approximately 44 nautical miles (NM) from the shore of Kauai within the Barking Sands Underwater Range Extension area. All weapons would impact the water surface, with live ordnance detonating on the water surface or just below the water surface (approximately 10 feet deep). Net explosive weight for live ordnance ranges from 23 to 300 pounds. The water depth at the weapon impact location is over 4,600 meters.

Potential impacts to essential fish habitat including seafloor habitat and the water column, as well as potential impacts to federally managed fisheries, were assessed to account for direct and indirect effects. Potential impact categories include water column disturbance, detonation effects (physical and acoustic) and the introduction of military expended materials, metals, explosives, and explosion by-products resulting from munitions use. Based on this analysis the Air Force Civil Engineering Center has determined that the Proposed Action **will not adversely affect essential fish habitat**.

If you have any questions about any of the proposed activities or would like to provide conservation recommendations regarding this Essential Fish Habitat Assessment, please do not hesitate to contact either Ms. Amanda Robydek at (850) 882-8395; amanda.robydek.ctr@us.af.mil or myself at (210) 925-2741; michael.ackerman.2@us.af.mil

Sincerely,

Michael O Ackerman

Michael Ackerman
Program Manager
NEPA Division (AFCEC/CZN)

ATTACHMENT: Essential Fish Habitat Assessment for the Long Range Strike Weapon Systems Evaluation Program

LONG RANGE STRIKE WEAPON SYSTEMS EVALUATION PROGRAM

ESSENTIAL FISH HABITAT ASSESSMENT

Submitted To:

Habitat Conservation Division

NOAA Fisheries Service

Pacific Islands Regional Office

Submitted By:

Air Force Civil Engineer Center

Department of the Air Force

APRIL 2016

TABLE OF CONTENTS

List of Tables

List of Figures

List of Acronyms, Abbreviations, and Symbols

86 FWS	86 Fighter Weapons Squadron
AFB	Air Force Base
BSURE	Barking Sands Underwater Range Extension
CO	carbon monoxide
CO_2	carbon dioxide
DoD	Department of Defense
EA	Environmental Assessment
EEZ	Exclusive Economic Zone
EFH	Essential Fish Habitat
FEP	Fishery Ecosystem Plan
FMP	Fishery Management Plan
FTS	flight termination system
GPS	Global Positioning System
HAPC	habitat area of particular concern
HARM	High Anti-Radiation Missile
HRC	Hawaii Range Complex
IADS	Integrated Air Defense System
INS	Internal Navigation System
JASSM	Joint Air-to-Surface Standoff Missile
JASSM-ER	Joint Air-to-Surface Standoff Missile – Extended Range
JB	Joint Base
JDAM	Joint Direct Attack Munition
lb	pound
LJDAM	Laser Joint Direct Attack Munition
MALD	Miniature Air-Launched Decoy
MALD-J	Miniature Air-Launched Decoy – Jamming
mg/L	milligrams per liter
MSA	Magnuson-Stevens Fishery Conservation and Management Act
NEW	net explosive weight
nm	nautical mile
nm^2	square nautical mile
NAS	Naval Air Station
NMFS	National Marine Fisheries Service
PBX	plastic-bonded explosive
PMRF	Pacific Missile Range Facility
OEA	Overseas Environmental Assessment
SDB	Small Diameter Bomb
TM	telemetry
UXO	unexploded ordnance
WPRFMC	Western Pacific Regional Fishery Management Council
WSEP	Weapon Systems Evaluation Program

1.0 Introduction

1.1 Purpose and Need for the Proposed Action

This Essential Fish Habitat (EFH) Assessment is being submitted to fulfill requirements under the Magnuson-Stevens Fishery Conservation and Management Act (MSA). This document addresses air-to-surface missions using live ordnance in the Pacific Missile Range Facility (PMRF), as described in the associated *Environmental Assessment/Overseas Environmental Assessment (EA/OEA) for the Long Range Strike Weapon Systems Evaluation Program (WSEP)* (hereafter referred to as the Long Range WSEP EA/OEA). This EFH Assessment is meant to initiate the consultation process with the National Marine Fisheries Service (NMFS) pursuant to requirements of the MSA. The objectives of this EFH Assessment are to:

- Document all EFH that potentially occurs within the affected area.
- Identify the actions, as described in the associated EA/OEA, which have the potential to impact the documented EFH.
- Determine the effects these activities would likely have on EFH.

The Proposed Action of the associated EA/OEA consists of missions involving the use of live ordnance that may explode at the water surface or slightly below the water surface. The actions are detailed in Section 2, *Description of the Proposed Action*.

1.2 Scope of the Proposed Action

Air-to-surface activities addressed in this document correspond to the missions described as the Proposed Action of the associated Long Range WSEP EA/OEA. All activities will take place within the PMRF, which is located in Hawaii on and off the western shores of the island of Kauai and includes broad ocean areas to the north, south, and west (Figure 1-1). There would be no ground-based or nearshore activities requiring the use of any shoreline areas of Kauai; all aspects and associated impacts from Long Range Strike WSEP missions would occur over open ocean areas. PMRF, as part of the U.S. Navy's Hawaii Range Complex (HRC), is a Major Range and Test Facility Base and, as such, supports the full spectrum of Department of Defense (DoD) test and evaluation requirements. PMRF is also the world's largest instrumented, multi-environment military testing and training range capable of supporting subsurface, surface, air, and space operations. The PMRF includes 1,020 square nautical miles (nm^2) of instrumented ocean areas at depths between 1,800 feet (549 meters) and 15,000 feet (4,572 meters), 42,000 nm^2 of controlled airspace, and a temporary operating area covering 2.1 million nm^2 of ocean area.

Within the PMRF, activities would specifically occur in the Barking Sands Underwater Range Extension (BSURE) area, which lies in Warning Area 188A (W-188A) (Figure 1-2). The BSURE consists of about 900 nm^2 of instrumented underwater ranges, encompassing the deepwater portion of the PMRF and providing over 80 percent of PMRF's underwater scoring capability. The BSURE facilitates training, tactics, development, and test and evaluation for air, surface, and subsurface weapons systems in deep water. It provides a full spectrum of range support, including radar, underwater instrumentation, telemetry, electronic warfare, remote target command and control, communications, data display and processing, and target/weapon launching and recovery facilities. The underwater tracking system begins 9 nautical miles (nm) (17 kilometers) from the north shore of Kauai and extends out to 50 nm (93 kilometers) from shore. Long Range Strike WSEP missions would employ live weapons with long flight paths requiring large amounts of airspace and conclude with weapon impact and surface or subsurface detonations within the BSURE instrumented range. In this document, the BSURE may also be referred to as the study area.

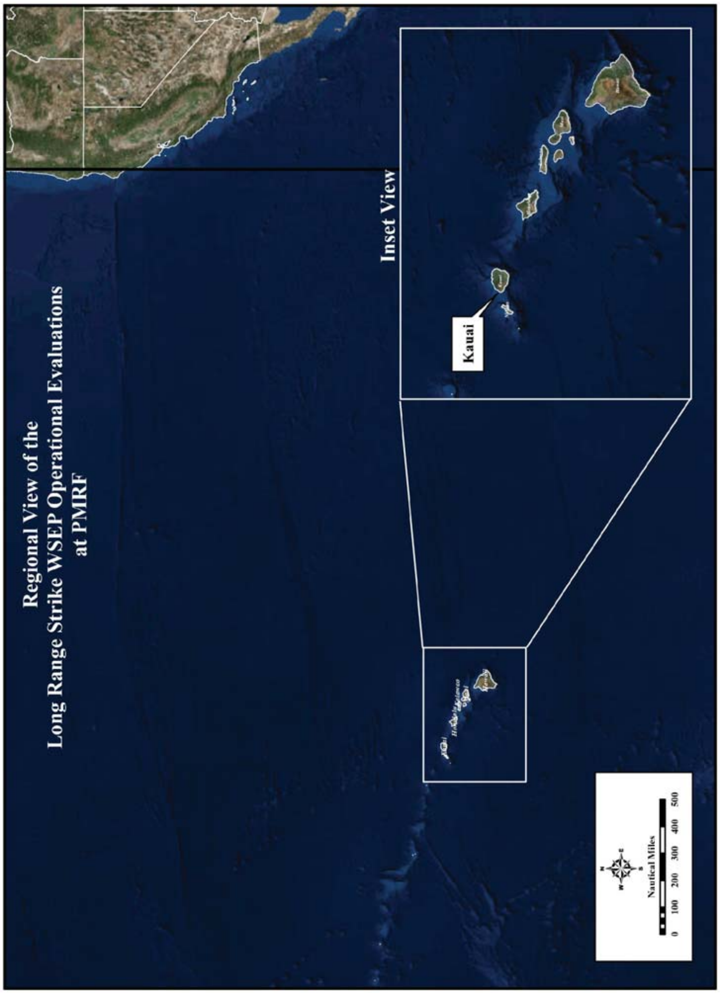


Figure 1-1. Regional Location of Long Range Strike WSEP Evaluation Activities

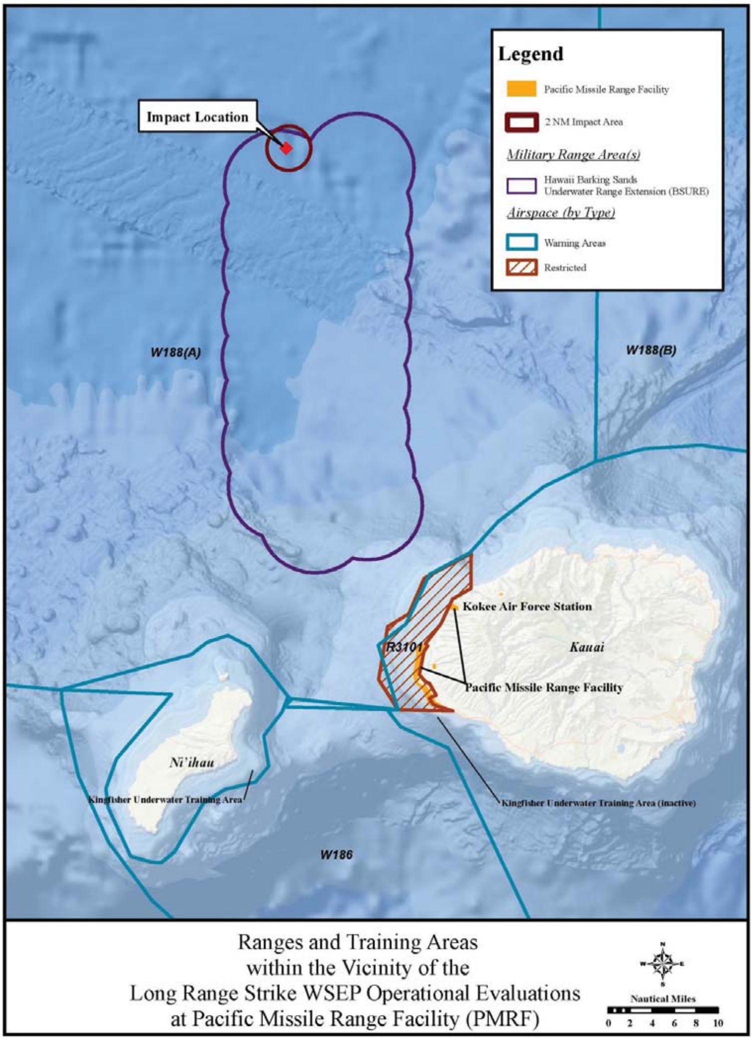


Figure 1-2. Pacific Missile Range Facility on Kauai, Hawaii

1.3 Magnuson-Stevens Fishery Conservation and Management Act

The MSA governs commercial fishing within the U.S. Exclusive Economic Zone (EEZ) (from state waters to about 200 nm offshore). The MSA requires that federal agencies consult with NMFS for any actions authorized, funded, or undertaken that may adversely affect EFH for any managed fishery. EFH is defined as the waters and substrate necessary for federally managed species to spawn, breed, feed, or grow to maturity. "Substrate" is defined as sediment, hardbottom, underwater structures, and associated biological communities and includes artificial reefs and shipwrecks. "Waters" are defined as aquatic areas and their chemical and biological properties (i.e., water quality). An "adverse effect" is any impact that reduces the quality or quantity of EFH. Adverse effects may be direct, such as physical disruption or contamination, or indirect, such as loss of prey or reduction in fecundity. Federal agencies are required to consult with NMFS for actions that may adversely affect EFH. If applicable, NMFS provides conservation recommendations to federal agencies for avoiding or mitigating potential impacts.

2.0 Description of the Proposed Action

Due to threats to national security, increased testing and training missions involving air-to-surface activities have been directed by the DoD. Accordingly, the U.S. Air Force seeks the ability to conduct operational evaluations of all phases of long range strike weapons and other munitions within the HRC. The actions would fulfill the Air Force's requirement to evaluate full-scale maneuvers for such weapons, including scoring capabilities, under operationally realistic scenarios.

The action will take place in the BSURE area of the PMRF, offshore of Kauai, Hawaii. Missions are planned to begin in summer 2016 and continue for the following five years. The 86th Fighter Weapons Squadron (86 FWS) is the test execution organization under the 53rd Wing for all WSEP deployments. WSEP test objectives are to evaluate air-to-surface and maritime weapon employment data, evaluate tactics, techniques, and procedures in an operationally realistic environment and to determine the impact of tactics, techniques, and procedures on combat Air Force training. The munitions associated with the proposed actions are not part of a typical unit's training allocations, and prior to attending a WSEP evaluation, most pilots and weapon systems officers have only dropped weapons in simulators or used the aircraft's simulation mode. Without WSEP operations, pilots would be using these weapons for the first time in combat. On average, half of the participants in each unit drop an actual weapon for the first time during a WSEP evaluation. Consequently, WSEP is a military readiness activity and is the last opportunity for squadrons to receive operational training and evaluation before they deploy.

In this document, *air-to-surface activities* refer to the deployment of missiles and bombs from aircraft to the water surface. Depending on the requirements of a given mission, munitions may be inert (containing no explosives) or live (contain explosive charges). Live munitions may detonate at or slightly below the water surface. The following subsections describe aircraft operations, weapons used, and typical mission procedures.

2.1 Aircraft Operations

Aircraft used for munition releases would include bombers and fighter aircraft. Additional airborne assets, such as the P-3 Orion and the P-8 Poseidon, would be used to relay telemetry (TM) and flight termination system streams between the weapon and ground stations. Other support aircraft would be associated with range clearance activities before and during the mission and air-to-air refueling operations. All weapon delivery aircraft would originate from an outbase and fly into military controlled airspace prior to employment. Due to long transit times between the outbase and mission location, air-to-air refueling may be conducted in either W-188A, W-188B, or W-189. Bombers, such as the B-1, would deliver the weapons, conduct air-to-air refueling, and return to their originating base as part of one sortie. However, when fighter aircraft are used, the distance and corresponding transit time to the various potential originating bases would make return flights after each mission day impractical. In these cases, the aircraft would temporarily (for less than one week) park overnight at Hickam AFB and would return to their home base at the conclusion of each mission set. Multiple weapon-release aircraft would be used during each mission, each potentially releasing multiple munitions. Each Long Range Strike WSEP mission set would occur over a maximum of five consecutive days per year. Approximately 10 Air Force personnel would be on temporary duty to support each mission set. Table 2-1 summarizes potential aircraft use proposed to support Long Range Strike WSEP missions.

Table 2-1. Summary of Example Aircraft Used During Long Range Strike WSEP Missions

Type	Example Aircraft	Purpose	Potential Outbases
Bombers	B-1, B-2, B-52	Weapon release	Ellsworth AFB; Dyess AFB; Barksdale, AFB; Whiteman AFB; Minot AFB
Fighter aircraft	F-15, F-16, F-22, F-35	Weapon release, chase aircraft, range clearance	Mountain Home AFB; Nellis AFB; Hill AFB; JB Hickam-Pearl Harbor JB Elmendorf-Richardson; JB Langley-Eustis
Refueling tankers	KC-135	Air-to-air refueling	McConnell, AFB
Surveillance	P-3, P-8	TM and FTS relays	Pt. Mugu, NAS
Helicopters	S-61N	Range clearance, protected species surveys	PMRF
Cargo aircraft	C-130, C-26	Range clearance, protected species surveys	U.S. Coast Guard; PMRF

AFB = Air Force Base; FTS = flight termination system; JB = Joint Base; NAS = Naval Air Station; PMRF = Pacific Missile Range Facility; TM = telemetry

Aircraft flight maneuver operations and weapon release would be conducted in W-188A. Chase aircraft may be used to evaluate weapon release and to track weapons. Flight operations and weapons delivery would be in accordance with published Air Force directives and weapon operational release parameters, as well as all applicable Navy safety regulations and criteria established specifically for PMRF. Aircraft supporting Long Range Strike WSEP missions would primarily operate at high altitudes, only flying below 3,000 for a limited time as needed to escort nonmilitary vessels outside the hazard area or for monitoring the area for protected marine species (e.g., marine mammals and sea turtles). Protected marine species aerial surveys would be temporary and would focus on an area surrounding the weapon impact point on the water. Range clearance procedures for each mission would cover a much larger area for human safety. Weapon release parameters would be conducted as approved by PMRF Range Safety. Weapon release parameters would be conducted as approved by PMRF Range Safety. Daily mission briefs would specify planned release conditions for each mission. Aircraft and weapons would be tracked for time, space, and position information. The 86 FWS test director would coordinate with the PMRF Range Safety Officer, Operations Conductor, Range Facility Control Officer, and other applicable mission control personnel for aircraft control, range clearance, and mission safety. Figure 2-1 shows a chase aircraft photograph taken by a chase aircraft of a long range missile being released and in flight.

Figure 2-1. Joint Air-to-Surface Stand-Off Missile (JASSM) Released

2.2 Description of Long Range Strike Weapons

Long Range Strike WSEP missions would release live (explosive) and inert (non-explosive) Joint Air-to-Surface Stand-Off Missile/Joint Air-to-Surface Stand-Off Missile-Extended Range (JASSM/JASSM-ER) JASSM/JASSM-ER, Small Diameter Bomb I and II (SDB I/II), High Anti-Radiation Missile (HARM), Joint Direct Attack Munition/ Laser Joint Direct Attack Munition (JDAM/LJDAM), and Miniature Air-Launched Decoy/ Miniature Air-Launched Decoy – Jamming (MALD/MALD-J). A description of each munition is included in the following subsections.

Joint Air-to-Surface Stand-Off Missile/Joint Air-to-Surface Stand-Off Missile-Extended Range (JASSM/JASSM-ER)

The JASSM (Figure 2-2) is a stealthy precision cruise missile designed for launch outside area defenses against hardened, medium-hardened, soft, and area type targets. The JASSM has a range of more than 200 nm (370 kilometers) and carries a 1,000-pound warhead with approximately 300 pounds of TNT equivalent net explosive weight (NEW). The specific explosive used is AFX-757, a type of plastic bonded explosive (PBX). The weapon has the capability to fly a preprogrammed route from launch to a target, using Global Positioning System (GPS) technology and an internal navigation system (INS) combined with a Terminal Area Model when available. Additionally, the weapon has a common low observable auto-routing function that gives the weapon the ability to find the route that best utilizes the low observable qualities of the JASSM. In either case, these routes can be modeled prior to weapon release. The JASSM-ER has additional fuel and a different engine for a greater range than the JASSM (500 nm [926 kilometers]) but maintains the same functionality of the JASSM.

Figure 2-2. Joint Air-to-Surface Stand-Off Missile (JASSM)

Small Diameter Bomb I/Small Diameter Bomb II (SDB I/SDB II)

The SDB I (Figure 2-3) is a 250-pound air-launched GPS-INS guided weapon for fixed soft to hardened targets. SDB II (Figure 2-3) expands the SDB I capability with network enabling and uses a tri-mode sensor infrared, millimeter, and semi-active laser to attack both fixed and movable targets. Both munitions have a range of up to 60 nm (111 kilometers). The SDB I contains 37 pounds of TNT-equivalent NEW, and the SDB II contains 23 pounds NEW. The explosive used in both the SDB I and SDB II is AFX-757.

Figure 2-3. Small Diameter Bomb I (left) and Small Diameter Bomb II (right)

High Anti-Radiation Missile (HARM)

The HARM (Figure 2-4) is a supersonic air-to-surface missile designed to seek and destroy enemy radar-equipped air defense systems. The HARM has a proportional guidance system that homes in on enemy radar emissions through fixed antenna and seeker head in the missile nose. It has a range of up to 80 nm (148 kilometers) and contains 45 pounds of TNT-equivalent NEW. The explosive used is PBXN-107.

Figure 2-4. High Anti-Radiation Missile (HARM)

Joint Direct Attack Munition / Laser Joint Direct Attack Munition (JDAM/LJDAM)

The JDAM (Figure 2-5) is a smart GPS-INS weapon that uses an unguided gravity bomb and adds a guidance and control kit, converting it to a precision-guided munition. The LJDAM variant adds a laser sensor to the JDAM, permitting guidance to a laser designated target. Both JDAM and LJDAM contain 192 pounds of TNT-equivalent NEW with multiple fusing options, with detonations occurring upon impact or with up to a 10-millisecond delay.

Figure 2-5. Joint Direct Attack Munition (JDAM)

Miniature Air Launched Decoy (MALD/MALD-J)

The MALD (Figure 2-6) is an air-launched, expendable decoy that will provide the Air Force the capability to simulate, deceive, decoy, and saturate an enemy's threat integrated air defense system (IADS). The MALD production has recently transitioned to include the MALD-J variant, which has the same decoy capability of the MALD plus the addition of jamming IADS. The MALD and MALD-J have ranges up to 500 nm (926 kilometers) to include a 200-nm (370-kilometer) dash with a 30-minute loiter mode. It has no warhead and, therefore, no detonation upon impact with the water surface would occur.

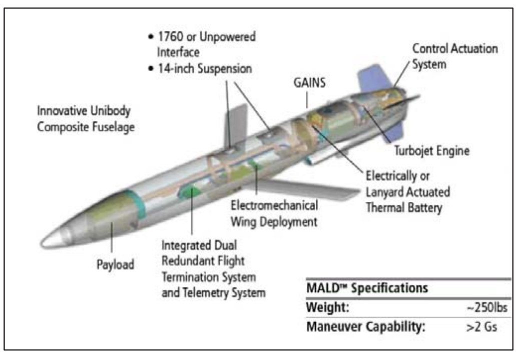


Figure 2-6. Miniature Air Launched Decoy (MALD/MALD-J)

2.3 Schedule and General Mission Procedures

Initial phases of the Long Range Strike WSEP operational evaluations are scheduled for September 2016 and will only consist of releasing one live JASSM or JASSM-ER and eight SDB I/II. All live releases for 2016 would result in surface detonations.

Follow-on evaluations planned for 2017 through 2021 will add employments of live and inert HARM, JDAM, and MALD, in addition to continued evaluation of JASSM, JASSM-ER, SDB I, and SDB II. Releases of live ordnance associated with 2017–2021 missions would result in either airbursts or surface or subsurface detonations (10-foot [3-meter] depth).

A typical mission day would consist of pre-mission checks, safety review, crew briefings, weather checks, clearing airspace, range clearance, mitigations/monitoring efforts, and other military protocols prior to launch of weapons. These standard operating procedures are usually done in the morning, and live range time may begin in late morning once all checks are complete and approval is granted from range control. The range would be closed to the public for a maximum of four hours per mission day.

Each long range strike weapon (JASSM/JASSM-ER, SDB I/II, HARM, MALD/MALD-J) would be released in W-188A and would follow a given flight path with programmed GPS waypoints to mark its course in the air. Long range strike weapons would complete their maximum flight range (up to 500-nm distance for JASSM-ER) at an altitude of approximately 18,000 feet above mean sea level and terminate at a specified location for scoring of the impact. The cruise time would vary among the munitions, but would be about 45 minutes for JASSM/JASSM-ER and 10 minutes for SDB I/II. Similarly, the time frame between employments of successive munitions would vary, but releases could be spaced by a maximum of one hour to account for the JASSM cruise time. The final impact point for all munitions is within the northern portion of the BSURE area, approximately 44 nm (81 kilometers) offshore of Kauai in approximate water depth of 15,240 feet (4,645 meters). The location of W-188A, along with the specific impact point, is shown on Figure 1-2 in Section 1. The routes and associated safety profiles would be contained within W-188A boundaries. The objective of the route designs is to complete full-scale evasive maneuvers that avoid simulated threats and would, therefore, not consist of a standard “paper clip” or regularly shaped route. The final impact point on the water surface would be programmed into the munitions for weapons scoring and evaluations. The JDAM/LJDAM munitions would also be set to impact at the same point on the water surface.

All missions would be conducted in accordance with applicable flight safety, hazard area, and launch parameter requirements established for PMRF. A weapon hazard region would be established, with the size and shape determined by the maximum distance a weapon could travel in any direction during its descent. The hazard area is typically adjusted for potential wind speed and direction, resulting in a maximum composite safety footprint for each mission (each footprint boundary is at least 10 nm from the Kauai coastline). This information is used to establish a launch exclusion area and aircraft hazard area. These exclusion areas must be verified to be clear of all non-mission and non-essential vessels and aircraft before live weapons are released. In addition, a buffer area must also be clear on the water surface so that vessels do not enter the exclusion area during the launch window. Prior to weapon release, a range sweep of the hazard area would be conducted by participating mission aircraft or other appropriate aircraft, potentially including S-61N helicopter, C-26 aircraft, fighter aircraft (F-15E, F-16, F-22), or the Coast Guard’s C-130 aircraft.

Surface vessels may be used to supplement range clearing activities. PMRF has used small water craft docked at the Port Allen public pier to keep nearshore areas clear of tour boats for some mission launch areas. However, for missions with large hazard areas that occur far offshore from Kauai, it would be impractical for these smaller vessels to conduct range clearance activities. The composite safety footprint weapons associated with Long Range Strike WSEP missions is anticipated to be rather large; therefore, it is likely that range clearing activities would be conducted solely by aircraft.

The Range Facility Control Officer is responsible for establishing hazard clearance areas, directing clearance and surveillance assets, and reporting range status to the Operations Conductor. The Control Officer is also responsible for submitting all Notices to Airmen and Notices to Mariners and requesting all Federal Aviation Administration airspace clearances. In addition to the human safety measures described above, protected species surveys are carried out before and after missions.

Immediate evaluations for JASSM/JASSM-ER and SDB I are needed; therefore, they are the only munitions being proposed for summer 2016 missions, currently set for September. Weapon release parameters for 2016 missions would involve a B-1 bomber releasing one live JASSM and fighter aircraft, such as F-15, F-16, or F-22, releasing live SDB I. Up to four SDB I munitions would be released simultaneously, similar to a ripple effect, each hitting the water surface within a few seconds of each other. However, the SDB I releases would occur separately from the JASSM. All releases would occur on the same mission day.

Follow-on years (2017–2021) would add evaluations of HARM, JDAM/LJDAM, and MALD/MALD-J, along with JASSM/JASSM-ER and SDB I/II. Similar to what is proposed for 2016 missions, up to four SDB I/II munitions could be released simultaneously, such that each ordnance would hit the water surface within a few seconds of each other. It is not known how many weapon releases or what combination of munitions would be released each day. However, aside from the SDB I/II releases, all other weapons would be released separately, impacting the water surface at different times.

Table 2-2 summarizes live and inert munition releases planned in the PMRF for 2016–2021.

Table 2-2. Proposed Munitions at PMRF (2016–2021)

Type of Munition	Live or Inert	NEW (lb)	Type of Aircraft	Detonation Scenario	Number of Proposed Releases					
					2016	2017	2018	2019	2020	2121
JASSM/ JASSM-ER	Live	300	Bomber, fighter	Surface	1	6	6	6	6	6
SDB I	Live	37	Bomber, fighter	Surface	8	30	30	30	30	30
SDB II	Live	23	Bomber, fighter	Surface	0	30	30	30	30	30
HARM	Live	45	Fighter	Surface	0	10	10	10	10	10
JDAM/LJDAM	Live	192	Bomber, fighter	Subsurface[1]	0	30	30	30	30	30
MALD/ MALD-J	Inert	N/A	Fighter	N/A	0	4	4	4	4	4

HARM = High Anti-Radiation Missile; JDAM = Joint Direct Attack Munition; lb = pounds; LJDAM = Laser Joint Direct Attack Munition; MALD = Miniature Air Launched Decoy; PMRF = Pacific Missile Range Facility; SDB = Small Diameter Bomb
1. Assumes a 10-millisecond time-delayed fuse resulting in detonation occurring at an approximate 10-foot water depth.

3.0 Essential Fish Habitat

The commercial fisheries of the United States are managed within a framework of overlapping international, federal, state, interstate, and tribal authorities. Individual states and territories generally have jurisdiction over fisheries in marine waters within 3 nm of their coast (there are limited exceptions to this distance). Federal jurisdiction includes fisheries in marine waters inside the U.S. EEZ, which encompasses the area (typically) from 3 nm to 200 nm offshore of any U.S. coastline (National Oceanic and Atmospheric Administration, 1996).

The MSA established jurisdiction over marine fishery resources within the U.S. EEZ. The act mandated the formation of eight fishery management councils, which share authority with NMFS to manage and conserve fisheries in federal waters within their geographic jurisdiction. The councils are required to prepare and maintain a Fishery Management Plan (FMP) for each managed fishery. The Western Pacific Regional Fishery Management Council (WPRFMC) manages fisheries located within the U.S. EEZ around the state of Hawaii (Hawaiian Islands EEZ), in addition to several other U.S. territories and islands. Amendments contained in the *Sustainable Fisheries Act of 1996* (Public Law 104-267) require the councils to identify EFH for each fishery covered under an FMP. EFH is defined as the waters and substrate necessary for spawning, breeding, or growth to maturity (16 USC 1802[10]). The term "fish" is defined as "finfish, mollusks, crustaceans, and all other forms of marine animals and plant life other than marine mammals and birds." In addition to EFH, the MSA also requires identification of habitat areas of particular concern (HAPCs). HAPCs are subsets of EFH that are rare, especially ecologically important, particularly susceptible to human-induced degradation, or located in environmentally stressed areas.

Similar to other regional councils, the WPRFMC historically managed fisheries through separate species-based FMPs, including the Bottomfish and Seamount Groundfish FMP, Crustaceans FMP, Precious Corals FMP, Coral Reef Ecosystems FMP, and Pelagic FMP. However, the WPRFMC has recently shifted toward an ecosystem-based approach, focusing fishery management activities on geographic areas that support various habitats and their associated species complexes rather than on individual species. Accordingly, the WPRFMC is in the process of replacing FMPs with Fishery Ecosystem Plans (FEPs). Five FEPs have been completed. FEPs associated with resources in the study area include the Hawaii Archipelago FEP (WPRFMC, 2009a) and the Pacific Pelagic Fisheries FEP (WPRFMC, 2009b).

Hawaii Archipelago Fishery Ecosystem Plan

The Hawaii Archipelago FEP does not establish new fishery management regulations but rather consolidates existing regulations contained in previous FMPs. The FEP identifies all demersal species (living on or near the seafloor) known to occur around the Hawaii Archipelago, designates them as one management unit, and incorporates all management provisions of the previous Bottomfish and Seamount Groundfish FMPs. In addition to bottomfish, the Hawaii Archipelago FEP also incorporates provisions of the previous Crustaceans, Precious Corals, and Coral Reef Ecosystems FMPs that are applicable to the area. EFH management units presently include bottomfish species (deep-slope and seamount species complexes consisting of snappers, jacks, armorhead, ratfish, Hawaiian grouper (*Epinephelus quernus*), and other similar taxa), crustaceans (spiny and slipper lobster species complex, deepwater shrimps, and Kona crab [*Ranina ranina*]), precious corals (non-reef building corals occurring below the euphotic zone, historically important in the jewelry trade), and coral reef ecosystems (separate designations for currently harvested and potentially harvested coral taxa and their associated fishes).

EFH for management units covered by the Hawaii Archipelago FEP is summarized in Table 3-1.

Table 3-1. Essential Fish Habitat Designated in the Hawaii Archipelago Fishery Ecosystem Plan

Management Unit, Species Assemblage, or Species Complex	Designated Essential Fish Habitat	
	Adults and Juveniles	Eggs and Larvae
Bottomfish		
Deep-slope species complex	The water column and all bottom habitat extending from the shoreline to a depth of 400 meters (200 fathoms).	The water column extending from the shoreline to the outer boundary of the EEZ, to a depth of 400 meters.
Seamount species complex	Adult only: all waters and bottom habitat bounded by latitude 29°–35° N and longitude 171° E–179° W, between 80 and 600 meters deep.	Eggs, larvae, and juveniles: the epipelagic zone (0 to 200 meters water depth) of all waters bounded by latitude 29°–35° N and longitude 171° E–179° W.
Crustaceans		
Spiny lobster complex and Kona crab	Bottom habitat from the shoreline to a depth of 100 meters throughout the Western Pacific Region.	The water column from the shoreline to the outer limit of the EEZ, to a depth of 150 meters throughout the Western Pacific Region.
Deepwater shrimp	Outer reef slopes at depths between 550 meters and 700 meters depth.	The water column and associated outer reef slopes between 300 meters and 700 meters deep.
Precious Corals	All life stages: all known precious coral beds of pink, gold, bamboo, and black coral. Currently known beds are located at Keahole Point, between Milolii and South Point, the Auau Channel, Makapuu, Kaena Point, the southern border of Kauai, Wespac Bed, Brooks Bank, and 180 Fathom Bank.	
Coral Reef Ecosystems		
Currently Harvested Coral Reef Taxa		
Acanthuridae	All bottom habitat and the adjacent water column from 0 to 50 fathoms.	The water column from the shoreline to the outer boundary of the EEZ to a depth of 50 fathoms.
Balistidae	All bottom habitat and the adjacent water column from 0 to 50 fathoms.	The water column from the shoreline to the outer boundary of the EEZ to a depth of 50 fathoms.
Carangidae	All bottom habitat and the adjacent water column from 0 to 50 fathoms.	The water column from the shoreline to the outer boundary of the EEZ to a depth of 50 fathoms.
Holocentridae	All rocky and coral areas and the adjacent water column from 0 to 50 fathoms.	The water column from the shoreline to the outer boundary of the EEZ to a depth of 50 fathoms.
Kuhliidae	All bottom habitat and the adjacent water column from 0 to 25 fathoms.	The water column from the shoreline to the outer boundary of the EEZ to a depth of 50 fathoms.
Kyphosidae	Adult only: all rocky and coral bottom habitat and the adjacent water column from 0 to 15 fathoms.	Eggs, larvae, and juveniles: the water column from the shoreline to the outer boundary of the EEZ to a depth of 50 fathoms.
Labridae	EFH for all life stages in the family Labridae is designated as the water column and all bottom habitat extending from the shoreline to the outer boundary of the EEZ to a depth of 50 fathoms.	
Mullidae	All rocky/coral and sand bottom habitat and adjacent water column from 0 to 50 fathoms.	The water column extending from the shoreline to the outer boundary of the EEZ to a depth of 50 fathoms.
Mugilidae	All sand and mud bottoms and the adjacent water	The water column from the shoreline to the outer limits

Table 3-1. Essential Fish Habitat Designated in the Hawaii Archipelago Fishery Ecosystem Plan, Cont'd

Management Unit, Species Assemblage, or Species Complex	Designated Essential Fish Habitat	
	Adults and Juveniles	Eggs and Larvae
	column from 0 to 25 fathoms.	of the EEZ to a depth of 50 fathoms.
Muraenidae	All rocky and coral areas and the adjacent water column from 0 to 50 fathoms.	The water column from the shoreline to the outer boundary of the EEZ to a depth of 50 fathoms.
Octopodidae	Adults, juveniles, and demersal eggs: all coral, rocky, and sand bottom areas from 0 to 50 fathoms.	Larvae only: the water column from the shoreline to the outer limits of the EEZ to a depth of 50 fathoms.
Polynemidae	All rocky/coral and sand bottom habitat and adjacent water column from 0 to 50 fathoms.	The water column from the shoreline to the outer boundary of the EEZ to a depth of 50 fathoms.
Priacanthidae	All rocky/coral and sand bottom habitat and adjacent water column from 0 to 50 fathoms.	The water column from the shoreline to the outer boundary of the EEZ to a depth of 50 fathoms.
Scaridae	All bottom habitat and the adjacent water column from 0 to 50 fathoms.	The water column from the shoreline to the outer limit of the EEZ to a depth of 50 fathoms.
Siganidae	All bottom habitat and the adjacent water column from 0 to 50 fathoms.	The water column from the shoreline to the outer boundary of the EEZ to a depth of 50 fathoms.
Sphyraenidae	EFH for all life stages in the family Sphyraenidae is designated as the water column from the shoreline to the outer boundary of the EEZ to a depth of 50 fathoms.	
Turbinidae	All bottom habitat and the adjacent water column from 0 to 50 fathoms.	The water column from the shoreline to the outer boundary of the EEZ to a depth of 50 fathoms.
Aquarium species/taxa	All coral, rubble, or other hard-bottom features and the adjacent water column from 0 to 50 fathoms.	All waters from 0 to 50 fathoms from the shoreline to the limits of the EEZ.
Potentially Harvested Coral Reef Taxa		
All potentially harvested species (thousands of species)	EFH for all life stages of potentially harvested coral reef taxa is designated as the water column and bottom habitat from the shoreline to the outer boundary of the EEZ, to a depth of 50 fathoms (91 meters).	

EEZ = Exclusive Economic Zone

Adult bottomfish distribution in the Hawaii region is generally linked to physical habitat (U.S. Department of the Navy, 2013a). Many of the Pacific islands are volcanic peaks with steep drop-offs and little continental shelf habitat. Therefore, many of the bottomfish species managed by the WPRFMC are concentrated on the steep slopes of deepwater banks, with the 100-meter isobath commonly used as an index of bottomfish habitat. Adults are typically associated with hard substrate of high structural complexity. The distribution of preferred habitat is not well known, and populations typically exhibit a patchy distribution. To reduce complexity in EFH designations, the WPFRMC has designated bottomfish assemblages including deep-slope and seamount complexes. Bottomfish eggs and larvae are pelagic, floating at the surface until hatching and then drifting with ocean currents.

The WPRFMC has also designated HAPCs for managed species complexes. HAPCs associated with the Hawaii Archipelago FEP are identified in Table 3-2.

Table 3-2. Habitat Areas of Particular Concern Designated in the Hawaii Archipelago Fishery Ecosystem Plan

Species Complex	Habitat Areas of Particular Concern
Bottomfish and Seamount Groundfish (shallow-water and deep-water slope species only; no designation for seamount species)	1) All slopes and escarpments between 40 and 280 meters (20 and 140 fathoms). 2) Three known areas of juvenile opakapaka habitat; two off Oahu and one off Molokai.
Crustaceans (lobster complexes and Kona crab only; no designation for shrimps)	All banks in the Northwestern Hawaiian Islands with summits less than or equal to 30 meters (15 fathoms) from the surface.
Precious Corals	1) Deep-water species: the Makapuu bed, Wespac bed, and Brooks Banks bed. 2) Shallow-water black coral species: the Auau Channel.
Coral Reef Ecosystems	All no-take Marine Protected Areas identified in the previous FMP, all Pacific remote islands, and numerous other Marine Protected Areas, research sites, and coral reef habitats throughout the western Pacific.

FMP = Fishery Management Plan

Pacific Pelagic Fisheries Fishery Ecosystem Plan

The Pelagic Fisheries FEP provides for the management of targeted pelagic species, which are considered open-water species that are usually found away from the shore and are not associated with the seafloor. Pelagic species included in the FEP are found in tropical and temperate waters throughout the Pacific Ocean. Tunas, billfishes, and sharks are the primary types of species addressed by the FEP, although other species such as mahi mahi and squid are included as well. Distribution is variable and is affected by environmental conditions, ocean current patterns, and prey availability. Pelagic species may move considerable distances and cross numerous political boundaries. Therefore, the WPRFMC considers the FEP boundary to include all areas subject to pelagic fishing operations conducted by domestic (U.S.) vessels that are located 1) in the U.S. EEZ, including the State of Hawaii, the Territories of American Samoa and Guam, the Commonwealth of the Northern Mariana Islands, and the U.S. Pacific Remote Island Areas; and 2) on the high seas.

For purposes of EFH designation, managed pelagics are divided into four broad species assemblages, including temperate species, tropical species, sharks, and squid. The designation of these assemblages is based on similarity of ecological and habitat requirements of the included species. EFH for management units covered by the Pelagic Fisheries FEP is summarized in Table 3-3.

Table 3-3. Essential Fish Habitat Designated in the Pacific Pelagic Fishery Ecosystem Plan

Species Complex	Designated Essential Fish Habitat	
	Adults and Juveniles	Eggs and Larvae
Temperate species Tropical species Sharks Squid	The water column down to a depth of 1,000 meters (500 fathoms), from the shoreline to the outer limit of the EEZ.	The water column down to a depth of 200 meters (100 fathoms), from the shoreline to the outer limit of the EEZ.

EEZ = Exclusive Economic Zone

The WPRFMC has identified HAPCs as the water column down to 1,000 meters that occurs above all seamounts and banks within the EEZ shallower than 2,000 meters (1,000 fathoms). Although these deep bottom features do not necessarily constitute EFH themselves, they influence the overlying water column, particularly by facilitating ocean mixing and other processes that lead to greater biological productivity.

Figure 3-1 shows all EFH and HAPCs in the vicinity of the study area.

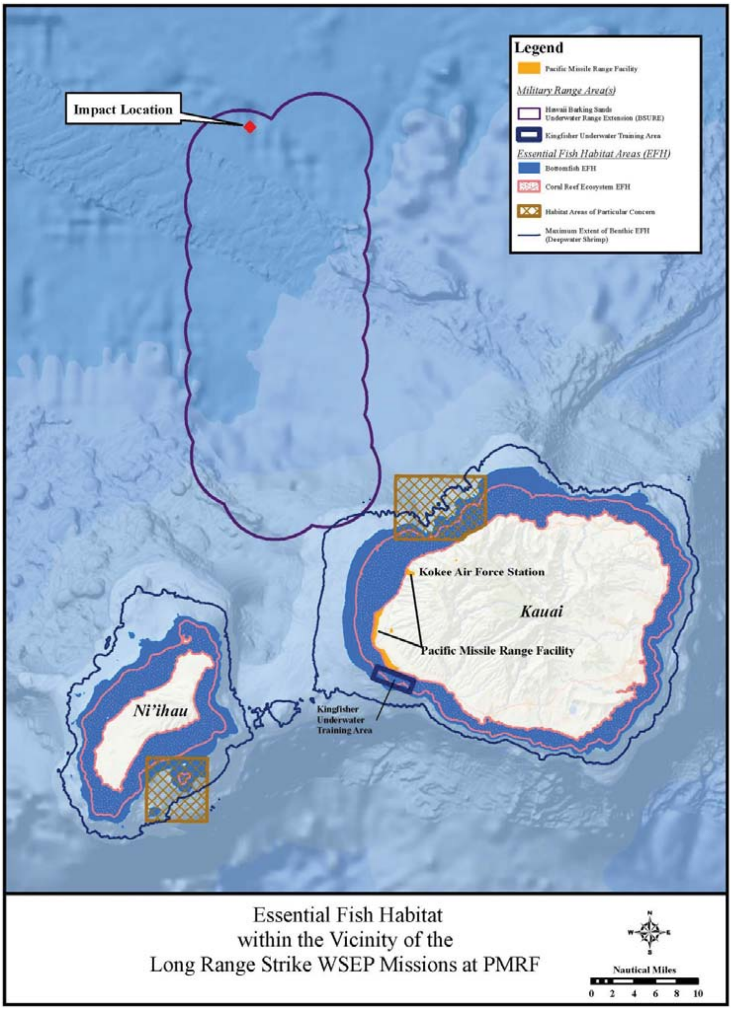


Figure 3-1. Essential Fish Habitat in the Study Area

4.0 Assessment of Impacts

The potential impacts associated with Long Range Strike WSEP missions on EFH are discussed in this section. Potential impact categories include physical disturbance and alteration of water and sediment quality due to the deposition of military expended materials, metals, explosives, explosion byproducts, and other chemical materials. In addition to EFH, potential impacts to managed species resulting from detonations are evaluated. Analysis is based on the level of activity identified as the Preferred Alternative in the Long Range Strike WSEP EA/OEA.

4.1 Essential Fish Habitat

The MSA requires federal agencies to prepare an assessment for any action that may adversely affect EFH. Adverse effects to EFH are defined as those that reduce the quality and/or quantity of this habitat. Adverse effects may include direct or indirect physical, chemical, or biological alterations of waters or substrate, and loss of, or injury to, benthic organisms, prey species and their habitat, and other ecosystem components. EFH designated by the WPRFMC is identified in Section 3. EFH is present within the northern portion of the BSURE area for some but not all management units/life stages, as summarized below.

Bottomfish. Bottom habitat EFH for adults and juveniles generally extends from the shore to a maximum water depth of 400 meters (for deep-slope species) but also includes an area to 600 meters deep for seamount species. Water depth at the Long Range Strike WSEP weapon impact area is approximately 4,600 meters, which is beyond the EFH boundary for adult and juvenile life stages. The mission area does not coincide with the deeper seamount species area. EFH for the eggs and larvae of deep-slope species includes the water column from the shoreline to the EEZ boundary. Therefore, this EFH component is present in the study area.

Crustaceans. Adult and juvenile bottom habitat EFH is not present in the northern BSURE area because of the water depth (maximum depth of 100 meters). However, similar to the bottomfish management unit, egg and larvae EFH for lobsters includes the water column from the shoreline to the EEZ boundary.

Precious corals. None of the identified precious coral beds occur within the study area. The nearest is a black coral bed located near the southern shore of Kauai.

Coral reef ecosystems. EFH for adult and juvenile life stages of currently harvested and potentially harvested corals generally includes bottom habitat to a depth of 50 fathoms (91 meters). Water depth at the Long Range Strike WSEP weapon impact area is approximately 4,600 meters, which is beyond this EFH boundary. EFH for eggs and larvae (and other life stages in a few instances) of currently harvested corals and all life stages of potentially harvested corals consists of the water column from the shoreline to the EEZ boundary. Therefore, this EFH component is present in the study area.

Pelagic fishery. Pelagic species EFH consists of the water column from the shoreline to the EEZ boundary. Therefore, this EFH component is present in the study area.

HAPCs. No HAPCs are present at the Long Range Strike WSEP weapon impact area for any management unit.

In summary, EFH in the Long Range Strike WSEP weapon impact area consists of the water column, from the surface to varying depths (maximum depth of 1,000 meters). The impact area is located well beyond seafloor EFH, and the potential for expended items to be moved into designated bottom habitat by water currents is considered negligible. Water quality in the BSURE area is considered excellent, as land-based runoff and effluent is generally confined to the neritic zone near the shoreline (U. S. Department of the Navy, 2008). Water depth increases quickly from the Kauai shoreline, and the open ocean around the Hawaiian Islands generally has high water clarity, low quantities of suspended materials, and low concentrations of trace metals and hydrocarbons. The coastal current system around the Hawaiian Islands has a strong flow and exchange with offshore waters, diluting and dispersing sediments and pollutants. Offshore water patterns are characterized by large-scale currents, deep eddies, storm swells, and wind swells. Impacts to the water column could occur due to physical disturbance, military expended materials, and the introduction of metals, explosive material, explosion byproducts, and other chemical materials. Each of these categories is discussed below.

Physical Disturbance

Explosions associated with Long Range Strike WSEP missions would occur at or near the water surface and would, therefore, not disturb the substrate. However, the shock wave resulting from an explosion could affect the pelagic water column, which is habitat for the eggs and larvae of numerous managed species, as well as for adult and juvenile stages of pelagic fish and squid. As described in the associated EA/OEA and Section 4.2 of this document, shock waves and cavitation in the water can cause mortality and injury to fish, including managed species, in the vicinity of an explosion. Invertebrates such as squid could be impacted as well. Although the number of individuals potentially affected is difficult to estimate due to variability in the local population density at the time of detonation, animal size, and position in the water column, detonations are not expected to have lasting effects on the survival, growth, or reproduction of any fish or invertebrate population. No substantial impacts to water column EFH resulting from physical disturbance are expected.

Military Expended Materials

Military expended materials potentially generated during Long Range Strike WSEP missions include inert munitions and fragments of exploded bombs and missiles. A small number of items may float on the water surface or in the water column for some time period, but most military expended materials would quickly sink to the ocean floor. Floating or sinking items would not physically alter the water in any meaningful or lasting manner and, therefore, would not adversely impact to the water column itself.

Metals

Various metals would be introduced into the water column through expended munitions. The casings, fins, and other parts of large munitions such as bombs and missiles are typically composed primarily of steel but usually also contain small amounts of lead, manganese, phosphorus, sulfur, copper, nickel, and several other metals (U.S. Department of the Navy, 2013b). Aluminum is also present in some explosive materials such as PBXN. Many metals occur naturally in seawater at varying concentrations and some, such as aluminum, would not necessarily be detrimental to the water column. However, some metals, such as lead, may be toxic in high concentrations.

Munitions and other metal items would sink to the seafloor and would typically undergo one of three processes: (1) enter the sediment where there is reduced oxygen content, (2) remain exposed on the ocean floor and begin to react with seawater, or (3) remain exposed on the ocean floor and become encrusted with marine organisms. The rate of deterioration would, therefore, depend on the specific composition of an item and its position relative to the seafloor/water column. Munitions located deep in the sediment would typically undergo slow deterioration. Some portion of the metal ions would bind to sediment particles. Metal materials exposed to seawater would begin to slowly corrode. This process typically creates a layer of corroded material between the seawater and metal, which slows the movement of the metal ions into the adjacent water column. A similar process would occur with munitions that become covered by marine growth. Direct exposure to seawater would be reduced, thereby decreasing the rate of corrosion.

Metal particles that migrate into the water column would be diluted by diffusion and the water movements typical of the open ocean environment around the Hawaiian Islands. Therefore, elevated concentrations would not be expected in any area. This expectation is supported by the results of two

U.S. Navy studies related to munitions use and water quality, as summarized in U.S. Department of the Navy (2013b). In one study, water quality sampling for lead, manganese, nickel, vanadium, and zinc was conducted at a shallow bombing range in Pamlico Sound off North Carolina immediately following a bomb training event with inert practice munitions. With the exception of nickel, all water quality parameters tested were within the state limits. The nickel concentration was substantially higher than the state criterion, although the concentration did not differ significantly from a control site located outside the bombing range. This suggests that bombing activities may not have been responsible for the elevated nickel concentration. The second study, conducted by the U.S. Marine Corps, included sediment and water quality sampling for 26 munitions constituents at multiple water training ranges. Metals included lead and magnesium. No levels were detected above screening values used at the water ranges.

Explosives and Explosion Byproducts

Explosives are complex chemical mixtures that may affect water quality through the byproducts of their detonation and the distribution of unconsumed explosives. Some of the more common types of explosive materials used in WSEP missions include tritonal and PBX. Tritonal is primarily composed of TNT, and PBX may be combined with RDX. Discussion in the remainder of this section will, therefore, consider TNT and RDX to be representative of all explosives.

During detonation, energetic compounds may undergo high-order (complete) detonation or low-order (incomplete) detonation. In addition, the compounds may fail to detonate altogether. High-order detonations consume almost all of the explosive material, with the remainder released into the environment as discrete particles. Analysis of live-fire detonations on terrestrial ranges have indicated that over 99.9 percent of TNT and RDX explosive material is typically consumed during a high-order detonation (Hewitt et al., 2003). Pennington et al. (2006) reported a median value of 0.006 percent and 0.02 percent for TNT and RDX residue, respectively, remaining after detonation. The total NEW for all combined munitions for all years of testing is 49,646 pounds. Dividing this number by 5 years (the time frame over which most of the weapons will be tested) results in a yearly use of 9,929 pounds of explosive material. Using the more conservative (higher) value of 0.02 percent for residual material, a total of about 2 pounds of explosive material could be deposited annually into the open ocean north of Kauai. For purposes of analysis, it may be assumed that all residual materials are deposited simultaneously and remain within the BSURE area and within the top 10 feet of the water column (10 feet is the maximum detonation depth scenario for any munition). In this case, the resulting concentration of explosive material would be about 1×10^{-13} milligrams per liter (mg/L). In reality, the materials would be deposited incrementally over time and would be dispersed throughout a larger surface area and water volume by water currents and waves. Although there are no state or federal water quality standards for the impact area (about 44 nm offshore), this value may be compared with the Department of Defense Range and Munitions Use working group marine screening value for the amount of C-4 (another type of explosive composed of mostly RDX) remaining after detonation (as discussed in U. S. Department of the Navy, 2013b). The screening value is 5 mg/L, which is many orders of magnitude greater than the concentration calculated above.

Various byproducts are produced during and immediately after detonation of TNT and RDX. During the brief time that a detonation is in progress, intermediate products may include carbon ions, nitrogen ions, oxygen ions, water, hydrogen cyanide, carbon monoxide, nitrogen gas, nitrous oxide, cyanic acid, and carbon dioxide (Becker, 1995). However, reactions quickly occur between the intermediate products and surrounding water, and the final products consist mainly of carbon (i.e., soot), carbon dioxide (CO_2), water, carbon monoxide (CO), and nitrogen gas (Naval Surface Warfare Center, 1975). These substances are natural components of seawater. Other products, occurring at substantially lower concentrations, include hydrogen, ammonia, methane, and hydrogen cyanide, among others.

After detonation, the residual explosive materials and detonation byproducts would ultimately be dispersed throughout the central Pacific Ocean by diffusion and by the action of wind, waves, and currents. A portion of the carbon compounds, such as CO and CO_2, would likely become incorporated into the carbonate system (alkalinity and pH buffering capacity of seawater). Some of the nitrogen and carbon compounds would be metabolized or assimilated by phytoplankton and bacteria. Most of the gas products that do not react with the water or become assimilated by organisms would be released to the atmosphere. Given that the residual concentration of explosive material would be small, that most of the explosion byproducts would be harmless or natural seawater constituents, and that byproducts would dissipate or be quickly diluted, impacts to water quality resulting from high-order detonations would be negligible.

Low-order detonations consume a lower percentage of the explosive and, therefore, a portion of the material is available for release into the environment. If the ordnance fails to detonate, the entire amount of energetic compound remains largely intact and is released to the environment over time as the munition casing corrodes. The likelihood of incomplete detonations is not quantified; however, the portion of munitions that could fail to detonate (i.e., duds) has been estimated at between about 3 and 5 percent (Walsh, 2007; RAND Corporation, 2005). Based on a potential dud rate of 5 percent, the number of live munitions, and NEW in each munition, it is estimated that about 2,482 pounds of explosive material could enter the BSURE area through unexploded munitions over the total testing time frame, or 496 pounds per year assuming a five-year project. However, most of this material would not be available to the marine environment immediately. Explosive material would diffuse into the water through screw threads, cracks, or pinholes in the munition casings. Therefore, movement of explosive material into the water column would be a slow process, potentially ranging from months to decades.

After leaving the munition casing, explosive material would enter the sediment or water column. Similar to the dispersion of explosive byproducts, as discussed above, chemical materials in the water column would be dispersed by currents and would eventually become uniformly distributed throughout the central Pacific Ocean. Explosive materials in the water column would also be subject to biotic (biological) and abiotic (physical and chemical) transformation and degradation, including hydrolysis, ultraviolet radiation exposure, and biodegradation. TNT is rapidly degraded in marine environments by biological and photochemical processes (Walker et al., 2006). Marine ecosystems are generally nitrogen-limited compared with freshwater systems, and marine microbes such as bacteria may, therefore, readily use TNT metabolites (e.g., ammonia and ammonium). TNT that is not biodegraded may bind to particulates, break down into dissolved organic matter, or dissolve into the water column. TNT is also subject to photochemical degradation, known as photolysis, whereby the ultraviolet component of sunlight degrades the compound into products similar to those produced by biodegradation. Photolysis is more effective in waters of shallower depth and/or with greater clarity. Uptake and metabolism of TNT has also been noted in phytoplankton. It is assumed that similar processes could affect other explosives such as RDX.

The results of studies of unexploded ordnance (UXO) in marine environments generally suggest that there is little overall impact to water quality resulting the leaching of explosive material. Various researchers have studied an area in Halifax Harbor, Nova Scotia, where UXO was deposited in 1945. Rodacy et al. (2000) reported that explosives signatures were detectable in 58 percent of water samples but that marine growth was observed on most of the exposed ordnance. TNT metabolites, suspected to result from biological decomposition, were also detected. In an earlier study (Darrach et al., 1998), sediment collected near unexploded (but broken) ordnance did not indicate the presence of TNT, whereas samples taken near intact ordnance showed trace explosives in the range of low parts per billion or high parts per trillion. The authors concluded that, after 50 years, the contents of broken munitions had dissolved, reacted, biodegraded, or photodegraded and that intact munitions appear to be slowly releasing their contents through corrosion pinholes or screw threads.

Hoffsommer et al. (1972) analyzed seawater (as well as sediment and ocean floor fauna) at known munition dumping sites off Washington State and South Carolina for the presence of TNT, RDX, tetryl, and ammonium perchlorate. None of these materials were found in any of the samples. Walker et al. (2006) sampled seawater and sediment at two offshore sites where underwater demolition was conducted using 10-pound charges of TNT and RDX. Residual TNT and RDX were below the detection limit in seawater, including samples collected in the plume within five minutes of detonation.

More recently, Smith and Marx (2016) investigated the Farallon De Medinilla bombing range in the Mariana Archipelago. The range has been used for live and inert firing and bombing since 1971. An undetermined quantity of UXO is present at the site. A total of 14 underwater surveys were conducted to evaluate physical conditions (e.g., craters, broken rocks or coral), algae, coral, invertebrates, fish, and sea turtles. Overall, conditions were indicative of a healthy ecosystem, and no evidence was found of adverse impacts to biological resources.

Other Chemical Materials

A small number of plastic component items could be produced by munition detonations. Because of their buoyancy and resistance to degradation, many types of plastic float and may travel long distances in the ocean (U.S. Commission on Ocean Policy, 2004). Plastics may serve as vehicles for transport of various pollutants, whether by binding them from seawater or from the constituents of the plastics themselves. Plastic items would eventually break down into smaller particles due to photolysis and mechanical wear (Law et al., 2010), although even microscale particles may retain the same potential for chemical effects (Setala et al., 2016). However, due to the very small number of plastic items produced and dispersion by wind and water currents, no detectable effects to water quality in the study area are expected.

Summary of Potential Impacts to Essential Fish Habitat

In summary, Long Range Strike WSEP missions in the BSURE area could potentially impact EFH by alteration of water quality through introduction of metals and chemical materials. Explosion byproducts could have temporary and localized effects but would be quickly dispersed and diluted by water currents (on the order of hours to days). Metals and explosives associated with UXO could be present at the mission site for long time periods (years to decades); however, effects to the water column would be limited to a small area around such items. Solid items could become corroded, encrusted, or covered with sediment, and constituents of unconsumed explosives would be subject to several physical, chemical, and biological processes that render the materials harmless or would otherwise dissipate them to undetectable levels. Physical disturbance of the water column would be temporary and would not alter the water in any measurable or lasting manner. Therefore, the Air Force considers that Long Range Strike WSEP mission activities described in this document **will not adversely affect EFH**.

4.2 Managed Species

As discussed in the associated EA/OEA, marine fish in general could potentially be impacted by noise or pressure resulting from detonations, ingestion of debris, and alteration of water and sediment quality. Some portion of affected fish could include species managed by the WPRFMC. Detonations at or below the water surface may generate overpressure (shock waves) and noise that move through the water column for some distance. The resulting effects to fish could include blast injury, barotrauma, hearing effects, and stress or behavioral reactions. Shock waves are often lethal to fish near a detonation (Continental Shelf Associates, 2004). At greater distance from the detonation point, the extent of mortality or injury depends on a number of factors such as fish size, body shape, and orientation in the water column (e.g., Keevin and Hempen, 1997; Lewis, 1996; O'Keeffe and Young, 1984; Wright, 1982). In addition, the expanding gases resulting from a detonation can set up a pulsating bubble whose recurring pressure waves also may contribute significantly to damage. Squid located near a detonation could experience similar effects, including mortality, injury, and behavioral reactions. Modeling used to predict safe ranges for fish and invertebrates (e.g., Young, 1991; O'Keeffe and Young, 1984) suggests the potential for animals located within a few hundred feet to several hundred feet of an underwater detonation to be killed. Injury, hearing effects, and behavioral effects may occur at greater distances. In addition to adult fish and squid, the eggs and larvae of managed species (including corals) could be physically impacted by explosions. The number of animals affected would depend on the local population density at the time of detonation and, in the case of fish, other factors such as size and position in the water. Variations in abundance, distribution, species composition, and distance from the detonation point make it impractical to predict the number of animals affected at any specific site.

Most fish and squid species experience large numbers of natural mortalities, and a relatively small level of additional mortality caused by Long Range Strike WSEP missions would not likely affect populations as a whole. Many missions involve inert munitions or detonation of live munitions at the water surface. These scenarios would result in substantially less potential for mortality. Missions involving underwater detonations would be spread over time. Generally, it is not expected that large numbers of managed species would be killed, injured, or harassed as a result of underwater detonations or that any population would be significantly affected. As a reference point, monitoring during the shock trial of the Navy destroyer *USS John Paul Jones*, in which a 10,000-pound charge was detonated underwater, documented about 100 dead fish (presumably at the surface; underwater surveys were not reported) (U.S. Department of the Navy, 1998). Behavioral changes are not expected to have lasting effects on the survival, growth, or reproduction of fish or squid populations.

Military expended materials such as small fragments of exploded munitions could sink to the seafloor and be ingested by fish that forage for food items on or within the substrate. Overall, the potential for ingesting expended materials would be limited to individual fish that might consume an item and experience a negative (injurious) effect. While ingestion of expended materials could result in lethal or sub-lethal effects to a small number of individuals, the likelihood of a fish encountering an expended item is low based on the dispersed nature of the materials. Furthermore, an encounter may not lead to ingestion, and ingestion would not necessarily cause injury. The number of fish potentially impacted would be low compared with overall population numbers, and population-level effects would not be expected.

Managed fish and squid species could potentially be impacted due to degradation of water and sediment quality resulting from deposition of chemical materials and metals. Chemical materials and metals would enter the water column in the form of explosive material, detonation byproducts, and metals from munitions casings and fragments. However, as discussed in Section 4.1 above, these materials would have an overall negligible effect on water and sediment quality and would not result in degradation of the physical marine environment. No effects to the health or viability of fish or squid populations or individuals would be expected.

Prey items for adult and juvenile life stages of the various managed species generally include crustaceans, cephalopods, and fish (see WPRFMC, 2009a, 2009b). Prey items for larval stages consist of plankton. Prey species would be subject to the same types of potential impacts as those discussed for managed species, including physical impacts from detonations and effects to sediment and water quality from metals and explosives. Decreased availability of food items could negatively affect managed species. However, similar to the preceding discussion, overall impacts to water and sediment quality would be negligible, and physical impacts would have no detectable effect to prey species populations.

5.0 Conclusions

Analysis in Section 4 identified the potential for EFH and managed species to be affected by detonations, military expended materials, metals, and explosives and other chemical materials. Conclusions are summarized below.

- Physical disturbance of the water column by detonations and sinking military expended materials would not alter the water column in any meaningful or lasting manner.
- Metals resulting from intact munitions and munition fragments would have long-term occurrence in the study area and would slowly enter the water column. Metal ions would be quickly diluted by diffusion and water movement, and there would be no effect to water quality.
- Explosives and explosion byproducts would be introduced to the water column during testing. Almost all the explosive compounds would be consumed immediately in most cases, and residual materials would be broken down by various processes, assimilated, or diluted. Intact compounds in UXO would persist long term and would escape slowly to the water column. These materials would undergo the same processes described above. The results of studies indicate there would be no effects or minimal effects on the water column.
- A small number of managed species and their prey items could be physically impacted by detonations, but there would be no effect to populations of any species.

Based on these conclusions, the Air Force believes **there will be no adverse effects to EFH or federally managed species** as a result of Long Range Strike WSEP missions.

6.0 List of Preparers

Amanda Robydek, Environmental Scientist
Leidos
Eglin AFB Natural Resources
107 Highway 85 North
Niceville, FL 32578
(850) 882-8395
amanda.robydek.ctr@eglin.af.mil

Rick Combs, Environmental Scientist
Leidos
1140 Eglin Parkway
Shalimar, FL 32579
(850) 609-3459
ronald.r.combs@leidos.com

7.0 References

Becker, N. M. (1995). *Fate of Selected High Explosives in the Environment: A Literature Review*. Los Alamos National Laboratory. LAUR-95-1018. March 1995.

Continental Shelf Associates (CSA) (2004). Explosive removal of offshore structures – information synthesis report. U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2003-070. 181 pp. + app.

Darrach, M. R., A. Chutjian, and G. A. Plett (1998). Trace Explosives Signatures from World War II Unexploded Undersea Ordnance. Environmental Science Technology, 1998, 32(9), pp 1354-1358. DOI: 10.1021/es970992h.

Hewitt, A. D., T. F. Jenkins, T. A. Ranney, J. A. Stark, M. E. Walsh, S. Taylor, M. R. Walsh, D. J. Lambert, N. M. Perron, N. H. Collins, and R. Karn (2003). Estimates for Explosives Residue from the Detonation of Army Munitions. U.S. Army Corps of Engineers ERDC/CRREL TR-03-16. September 2003.

Hoffsommer, J. C., D. J. Glover, and J. M. Rosen (1972). Analysis of Explosives in Sea Water and in Ocean Floor Sediment and Fauna. Naval Ordnance Laboratory, White Oak, Silver Spring, MD. NOTLR 72-215. September 1972.

Keevin, T. M., and G. L. Hempen (1997). *The Environmental Effects of Underwater Explosions with Methods to Mitigate Impacts*. U.S. Army Corps of Engineers, St. Louis District.

Law, K. L., S. Moret-Ferguson, N. A. Maximenko, G. Proskurowski, E. E. Peacock, J. Hafner, and C. M. Reddy (2010). Plastic Accumulation in the North Atlantic Subtropical Gyre. *Science* 329, 1185 (2010). DOI: 10.1126/science.1192321.

Lewis, J. A. (1996). *Effects of Underwater Explosions on Life in the Sea*. Department of Defence (Australia), Defence and Science Technology Organisation. August 1996.

National Oceanic and Atmospheric Administration (1996). Magnuson Act provisions; Consolidation and update of regulations. [Proposed rule; request for comments]. Federal Register, 61(85), 19390-19429.

Naval Surface Warfare Center (1975). A Chemical Monitoring Program of the Explosion Products in Underwater Explosion Tests. NSWC Technical Report NSWC/WOL/TR. Naval Surface Weapons Center, White Oak Laboratory, Silver Spring, MD. 4 April 1975.

O'Keefe, D. J., and G. A. Young (1984). *Handbook on the Environmental Effects of Underwater Explosions*. Naval Surface Weapons Center, Dahlgren, Virginia. September 13.

Pennington, J. C., T. F. Jenkins, G. Ampleman, S. Thiboutot, J. M. Brannon, A. D. Hewitt, J. Lewis, S. Brochu, E. Diaz, M. R. Walsh, M. E. Walsh, S. Taylor, J. C. Lynch, J. Clausen, T. A. Ranney, C. A. Ramsey, C. A. Hayes, C. L. Grant, C. M. Collins, S. R. Bigl, S. Yost, and K. Dontsova (2006). Distribution and Fate of Energetics on DoD Test and Training Ranges: Final Report. U.S. Army Corps of Engineers ERDC TR-06-13. November 2006.

RAND Corporation (2005). *Unexploded Ordnance Cleanup Costs. Implications of Alternative Protocols*.

Rodacy, P. J., P. K. Walker, S. D. Reber, J. Phelan, and J. V. Andre (2000). *Explosive Detection in the Marine Environment and On Land Using Ion Mobility Spectroscopy: A Summary of Field Tests*. Sandia National Laboratories. Sandia Report SAND2000-0921. April 2000.

Setala, O. S., J. Norkko, and M. Lehtiniemi (2016). Feeding type affects microplastic ingestion in a coastal invertebrate community. Marine Pollution Bulletin 102 (2016) 95-101.

Smith, S. S., and D. E. Marx Jr. (2016). De-facto marine protection from a Navy bombing range: Farallon De Medinilla, Mariana Archipelago, 1997 to 2012. Marine Pollution Bulletin 102 (2016) 187-198.

U.S. Commission on Ocean Policy (2004). *An Ocean Blueprint for the 21st Century*. Final Report. Washington, DC 2004. ISBN#0–9759462–0–X.

U.S. Department of the Navy (1998). *Final Environmental Impact Statement, Shock-testing the SEAWOLF Submarine*. Washington, D.C.

U. S. Department of the Navy (2008). Barking Sands Underwater Range Expansion (BSURE) Refurbishment. Final Record of Categorical Exclusion/Overseas Environmental Assessment. March 2008.

U.S. Department of the Navy (2013a). Hawaii-Southern California Training and Testing Essential Fish Habitat Assessment. August 2013.

U.S. Department of the Navy (2013b). Hawaii-Southern California Testing and Training EIS/OEIS. Final EIS/OEIS August 2013.

Walker, S. W., C. L. Osburn, T. J. Boyd, L. J. Hamdan, R. B. Coffin, M. T. Montgomery, J. P. Smith, Q. X. Li,
C. Hennessee, F. Monteil, and J. Hawari (2006). *Mineralization of 2,4,6-Trinitrotoluene (TNT) in Coastal Waters and Sediments*. Naval Research Laboratory NRL/FR/6114-06-10, 135. August 21, 2006.

Walsh, Michael R. (2007). *Explosives Residues Resulting from the Detonation of Common Military Munitions: 2002-2006. Final Report*. U.S. Army Corps of Engineers ERDC/CRREL TR-07-2. February 2007.

Western Pacific Regional Fishery Management Council (WPRFMC) (2009a). *Fishery Ecosystem Plan for the Hawaii Archipelago*. September 4, 2009.

Western Pacific Regional Fishery Management Council (WPRFMC) (2009b). *Fishery Ecosystem Plan for Pacific Pelagic Fisheries of the Western Pacific Region*. September 24, 2009.

Wright, D. G. (1982). A Discussion Paper on the Effects of Explosives on Fish and Marine Mammals in the Waters of the Northwest Territories *Canadian Technical Report of Fisheries and Aquatic Sciences*. (pp. 1-16). Winnipeg, Manitoba: Western Region Department of Fisheries and Oceans.

Young, G. A. (1991). *Concise Methods for Predicting the Effects of Underwater Explosions on Marine Life*. Naval Surface Weapons Center, Research and Technology Department, Dahlgren, Virginia. July 1, 1991.

NMFS EFH Response Letter

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Pacific Islands Regional Office
1845 Wasp Blvd., Bldg 176
Honolulu, Hawaii 96818
(808) 725-5000 · Fax: (808) 725-5215

Michael Ackerman
Program Manager NEPA Division
Air Force Civil Engineer Center
Joint Base San Antonio Lackland Texas
2261 Hughes Ave., Ste. 155
JBSA Lackland, TX 78236-9853

May 19, 2016

Dear Mr. Ackerman:

The National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) has reviewed US Air Force's (USAF) April 19, 2016 Essential Fish Habitat (EFH) Assessment for the proposed Long Range Strike Weapon Systems Evaluation Program (WSEP) at the Pacific Missile Range Facility (PMRF) on Kauai, Hawaii.

The Proposed Action involves the USAF's 86th Fighter Weapons Squadron conducting operational evaluations of long range strike weapons and other munitions at PMRF, offshore of Kauai, Hawaii. Live (explosive) and inert (non-explosive) munitions would be released from multiple types of aircraft, including bombers and fighter aircraft, within military controlled airspace over the Pacific Ocean. The weapon impact point is approximately 44 nautical miles (NM) from the shore of Kauai within the Barking Sands Underwater Range Extension (BSURE) area. The water depth at the weapon impact location is over 4,600 meters. All weapons would impact the water surface, with live ordnance detonating on the water surface or just below the water surface (approximately 10 feet deep). Net explosive weight for live ordnance ranges from 23 to 300 pounds. Approximately 550 munition releases in total are proposed between the years 2016 and 2021.

NMFS appreciates UASF's efforts to reach out to us early for technical assistance. We also appreciate USAF thorough descriptions of EFH affected by the Proposed Action, and identification of effects to EFH. We cannot however agree with USAF determination that the Proposed Action "will not adversely affect essential fish habitat". Explosions in the weapon impact point area will result in lethal and sub lethal effects to NMFS managed species, and the release of contaminants into the water column. As such, we offer the following comments in accordance with the EFH provision of the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act) (50 C.F.R. § 600.905 – 930), also the National Environmental Policy Act (42 U.S.C. 4321 et seq.).

Magnuson-Stevens Act

Pursuant to the Magnuson-Stevens Act (MSA), the Secretary of Commerce, through NMFS, is responsible for the conservation and management of fishery resources found off the coasts of the United States. *See* 16 U.S.C. 1801 *et seq.* Section 1855(b)(2) of the MSA requires federal agencies to consult with NMFS, with respect to "any action authorized, funded, or undertaken, or proposed to be authorized, funded, or undertaken, by such agency that may adversely affect any essential fish habitat identified under this Act." The statute defines EFH as "those waters and substrates necessary to fish for spawning, breeding, feeding or growth to maturity." 16 U.S.C. 1802(10). Adverse effects on EFH are defined further as "any impact that reduces the quality and/or quantity of EFH," and may include "site-specific or habitat-wide impacts, including individual, cumulative or synergistic consequences of actions." 50 C.F.R. § 600.810(a). The consultation process allows NMFS to make a determination of the project's effects on EFH and provide Conservation Recommendations to the lead agency on actions that would adversely affect such habitat. *See* 16 U.S.C. 1855(b)(4)(A).

Essential Fish Habitat

The marine water column from the surface to varying depths (maximum depth of 1,000 meters) in and around the weapon impact area offshore of Kauai is designated as EFH and supports various life stages for the management unit species (MUS) identified under the Western Pacific Regional Fishery Management Council's Pelagic and Hawaii Archipelago Fishery Ecosystem Plans (FEPs). The MUS and life stages that may be found in these waters include: eggs and larvae of Coral Reef Ecosystem MUS (CRE-MUS); eggs and larvae of Bottomfish MUS (BMUS); eggs and larvae of Crustacean MUS (CMUS); and eggs, larvae, juveniles and adults of Pelagic MUS (PMUS). No HAPCs are present in the weapon impact area for any MUS.

Effects on EFH, MUS and prey include the following. The shock wave resulting from explosions damage fish swim bladders and rupture internal organs. Vibrations from detonations kill or damage fish eggs or larvae, and cause mortality and injury to fish in the vicinity of the explosion. Effects to fish could also include stress or behavioral reactions. Small fragments of exploded munitions can be ingested by fish that forage for food items. The MUS could also be impacted due to degradation of water and sediment quality resulting from deposition of chemical materials and metals. Chemical materials and metals would enter the water column in the form of explosive material, detonation byproducts, and metals from munitions casings and fragments. Some metals, such as lead, may be toxic in high concentrations. Explosives are complex chemical mixtures that may affect water quality through the byproducts of their detonation and the distribution of unconsumed explosives. Some of the more common types of explosive materials used by USAF as per the Proposed Action include tritonal and PBX, which produce various byproducts during and immediately after detonation. In addition, plastic component items could be produced by munition detonations.

NMFS appreciates USAF accurate identification of the EFH and MUS that will be affected by the Proposed Action and the efforts to analyze the impacts to water column and managed species. However, we cannot agree with USAF that the Proposed Action will not adversely affect EFH. While the specific level of adverse effect at the MUS population level is challenging to quantify, the definition of adverse effect to EFH is "any impact that reduces the quality and/or quantity of EFH". As described above there will be multiple types of impacts to EFH, which may not be minor, localized and/or temporary in nature.

We provide the following EFH Conservation Recommendations so USAF may avoid, minimize and offset these adverse effects to EFH.

EFH Conservation Recommendations

1. Reduce, to the greatest extent practicable, the area and volume of physical and chemical impact associated with any given munitions release in the weapons impact area to minimize adverse effects to EFH and manages species.

2. Locate the weapons impact area within the BSURE to avoid any fish aggregation sites. Selection of the weapons impact site needs to consider bathymetry and circulation patterns to minimize the presence of fauna. In addition, monitor the ocean surface at the weapons impact area prior to munitions release and avoid detonations if and when pelagic MUS are feeding and/or aggregations of bait are observed at the site.

3. Implement adaptive management; for example incorporate trigger points prior to the end of the 5 years of the Long Range Strike WSEP to evaluate whether the initial planned number of munition releases (approximately 550) can be reduced while meeting the mission needs.

4. Continue to gather information and undertake further analysis of impact to EFH and MUS associated with munitions release in Hawaiian waters. For example, determine the percent (%) of the larval pool present in offshore Hawaiian waters predicted to be killed by the variety of explosions, also the proportion of the total larval pool this constitutes, and how this affects MUS populations. In addition evaluate the extent of marine debris associated with munitions release, and the cumulative effects of this to EFH and MUS (recent deep sea explorations in the Pacific Islands Region highlight the concern of debris accumulating on the seafloor).

5. Implement initiatives to offset/compensate for the unavoidable impacts to water quality and MUS associated with USAF munitions release operations. Consider investments into stock enhancement programs, contributing to the marine resource management activities associated with the PMRF Integrated Natural Resources Management Plan, and undertake metal clean up and marine debris removal from shallow coral reef areas in the PMRF.

Please be advised that regulations (Section 305(b)(4)(B) of the MSA) to implement the EFH provisions of the MSA require that Federal action agencies provide a written response to this letter within 30 days of its receipt and at least 10 days prior to final approval of the action. A preliminary response is acceptable if final action cannot be completed within 30 days. The final response must include a description of measures to be required to avoid, mitigate, or offset the adverse impacts of the activity. If the response is inconsistent with our EFH Conservation Recommendations, an explanation of the reason for not implementing the recommendations must be provided.

Conclusion

In conclusion, NMFS appreciates USAF's efforts to describe EFH affected by the Proposed Action, and to analyze the effects on EFH. However, we cannot agree with USAF determination that the Proposed Action will not adversely affect EFH. Explosives and explosion byproducts would be introduced to the water column during testing in the weapon impact point area; metals resulting from intact munitions and munition fragments would slowly enter the water column; and physical impacts through detonations will have lethal and sub lethal effects to fish. We provide EFH Conservation Recommendations as per above for USAF to mitigate these impacts.

Please do not hesitate to contact Danielle Jayewardene at 808-725 5088 (danielle.jayewardene@noaa.gov) with any comments, questions or to request further technical assistance.

Sincerely,

Gerry Davis
Assistant Regional Administrator
Habitat Conservation Division

Cc by e-mail:
Amanda Robydek, Leidos
Rick Combs, Leidos
Rebecca Walker, WPRFMC

Air Force EFH Response Letter (June 22, 2016)

DEPARTMENT OF THE AIR FORCE
AIR FORCE CIVIL ENGINEER CENTER
JOINT BASE SAN ANTONIO LACKLAND TEXAS

AFCEC/CZN
2261 Hughes Ave., Ste. 155
JBSA Lackland, TX 78236-9853

22 June, 2016

Mr. Gerry Davis
Assistant Regional Administrator, Habitat Conservation Division
Pacific Islands Regional Office
National Oceanic and Atmospheric Administration
Inouye Regional Center
1845 Wasp Blvd, Building 176
Honolulu, HI 96818

SUBJECT: Air Force Responses to Essential Fish Habitat Conservation Recommendations for Long Range Strike Weapon Systems Evaluation Program

Dear Mr. Davis,

On behalf of the 86th Fighter Weapons Squadron (86 FWS), the Air Force has received and reviewed the National Oceanic and Atmospheric Administration's National Marine Fisheries Service's (NMFS's) letter dated May 19, 2016 in response to the Essential Fish Habitat (EFH) Assessment submitted on April 19, 2016. The letter correctly describes the 86 FWS's Proposed Action, acknowledges Air Force's thorough descriptions of EFH and identification of the effects on EFH, but disagreed with the Air Force's determination that the Proposed Action "will not adversely affect essential fish habitat".

Long Range Strike Weapon Systems Evaluation Program (WSEP) missions are proposed to occur over 40 nautical miles from shore, within the northern portion of the Barking Sands Underwater Range Extension (BSURE) area in water depth of over 4,600 meters. Activities include the release and detonation of live munitions from aircraft, with net explosive weights varying between 23 and 300 pounds. All detonations would occur either at the water surface or at a depth of three meters (10 feet). EFH in the weapon impact area primarily consists of the water column from the surface to a maximum of 1,000 meter water depth. Impacts to managed fisheries were also considered. Using the best available science, the Air Force found that impacts to water quality from physical disturbance, military expended materials, metals, explosives and explosion by-products, and other chemicals would have temporary and localized effects, but would be quickly dispersed, diluted, and would not alter water quality in any measureable or lasting manner. While managed species and prey items have the potential to be physically impacted by detonations in a very localized manner should the species be present in the immediate vicinity of the water column identified, these species experience large numbers of natural mortalities from other stressors and detonations from the proposed action are not anticipated to result in long-term population level effects to any species.

NMFS proposed five EFH Conservation Recommendations to avoid, minimize, and offset adverse effects to EFH. On June 6, 2016, a conference call was held with Ms. Danielle Jayewardene to discuss the recommendations, the Air Force's preliminary responses, and answer questions on the proposed action. Based on this discussion, the Air Force understands NMFS' concern with the inability to quantify the effects of potential impacts to EFH which is the direct result of a gap in the scientific knowledge on the EFH components within the open ocean areas of the Pacific. With this understanding, on behalf of the 86 FWS, the Air Force has prepared a response for each of the conservation recommendations, as stated below:

1. *Reduce, to the greatest extent practicable, the area and volume of physical and chemical impact associated with any given munitions release in the weapons impact area to minimize adverse effects to EFH and managed species.*

RESPONSE: It is not possible for the 86 FWS to reduce the area and volume of the physical and chemical impact. Munition performance in the marine environment is one of the objectives of the proposed action and therefore cannot be altered or minimized in some manner and still accomplish the operational testing objectives. Long Range Strike WSEP objectives are to evaluate maritime weapon employment data, tactics, techniques, and procedures of using weapons in an operationally realistic environment and to determine the impact of these tactics, techniques, and procedures on combat Air Force training. Any alteration would essentially change the characteristics of the weapons to something different than how the weapon would be used in real world operations and therefore would no longer meet the purpose and need of the proposed action.

2. *Locate the weapons impact area within the [Barking Sands Underwater Range Extension] BSURE to avoid any fish aggregation sites. Selection of weapons impact site needs to consider bathymetry and circulation patterns to minimize the presence of fauna. In addition, monitor the ocean surface at the weapons impact area prior to munitions release and avoid detonations if and when pelagic MUS are feeding and/or aggregations of bait are observed at the site.*

RESPONSE: The weapon impact area is a stationary location that has been pre-determined by the 86 FWS and has been used for acoustic analyses associated with Marine Mammal Protection Act (MMPA) and Endangered Species Act (ESA) consultations. The BSURE area provides conditions that are essential for realistic military training and testing activities. The ability to use the impact area meets the purpose and need of the proposed action, and these areas have been the subject of prior consultation and approvals by NMFS under the MMPA and ESA for other Service programs. The impact point would be pre-programmed into the weapons prior to launch. Relocation of the impact area at some time during the mission due to the presence of fish aggregations that will fluctuate in location, time, and size based on varying weather and sea state conditions is therefore not operationally feasible. Pre-mission and post-mission surveys of the impact area will be conducted aerially for the presence of MMPA and ESA-listed species (marine mammals and sea turtles). If protected species are observed within the impact area, munitions would not be released until the animals are observed to have exited the impact area, or thought to have exited the impact area based on its course and speed, or the impact area has been clear of sightings for 30 minutes. The ability to identify specific pelagic MUS and/or aggregations of baitfish from an aerial platform could only be accomplished if they are at or just below the water surface and sea state conditions are favorable. However, mitigation measures implemented for the protection of marine mammals and sea turtles would have the added benefit to fish aggregations that are also present, but not visible at the surface.

3. *Implement adaptive management for example incorporate trigger points prior to the end of the 5 years of the Long Range Strike WSEP to evaluate whether the initial planned number of munition releases (approximately 550) can be reduced while meeting the mission needs.*

RESPONSE: The 86 FWS's mission requirement is 550 munitions releases over the 5 year operational period. It is possible that weapon/aircraft availability, mechanical issues, inclement weather, and other environmental conditions may preclude the 86 FWS from releasing all of the munitions proposed for release over the 5 year timeframe, and that the number of munitions releases may vary from year to year. The 86 FWS will ensure that it does not exceed the number of munitions releases evaluated as part of the proposed action in any given year during the 5 year operational window.

4. *Continue to gather information and undertake further analysis of impact to EFH and MUS associated with munitions release in Hawaiian waters. For example, determine the percent (%) of the larval pool present in offshore Hawaiian waters predicted to be killed by the variety of explosions, also the proportion of the total larval pool this constitutes, and how this affects MUS populations. In addition evaluate the extent of marine debris associated with munitions release, and the cumulative effects of this to EFH and MUS (recent deep sea exploration in the Pacific Islands Region highlight the concern of debris accumulating on the seafloor).*

RESPONSE: The 86 FWS currently does not have the types of resources or expertise needed to conduct these types of scientific baseline studies. Furthermore, it would not be appropriate for the 86 FWS to use appropriated funds for purposes other than those directly associated with the 86 FWS objectives. The Air Force has used the best available science to analyze the action and prepare its National Environmental Policy Act (NEPA), EFH, MMPA, and ESA documents. If new scientific information becomes available that changes the analysis or conclusions in those documents, then the Air Force will follow appropriate regulatory processes and reinitiate consultation if necessary. As part of the NEPA process, the Air Force will include this correspondence as a part of the Administrative Record and will consider it for future consultations.

5. *Implement initiatives to offset/compensate for the unavoidable impacts to water quality and MUS associated with USAF munitions release operations. Consider investments into stock enhancement programs, contributing to the marine resource management activities associated with the PMRF Integrated Natural Resources Management Plan, and*

undertake metal clean up and marine debris removal from shallow coral reef areas in the PMRF.

RESPONSE: Military expended materials associated with Long Range Strike WSEP mission activities would not be released into shallow coral reef areas or near shore habitat areas and therefore debris removal in those areas by the 86 FWS is not warranted. Furthermore, an Environmental Assessment is being prepared for this proposed action and impacts to water quality are found to be insignificant upon evaluation using the best available science about fate and transport of constituents. The PMRF Integrated Natural Resources Management Plan only covers the installation and nearshore waters adjacent to the installation, so there are no projects that relate to the marine resources analyzed under the proposed action.

The Air Force appreciates your timely response and coordination efforts in support of this high-priority Air Force mission. We hope these responses adequately addressed your recommendations and concerns. If there are further questions or issues, please contact either Ms. Amanda Robydek (850) 882-8395; amanda.robydek.ctr@us.af.mil or myself at (210) 925-2741; michael.ackerman.2@us.af.mil

Sincerely,

Michael Ackerman
Program Manager
AFCEC NEPA Division (AFCEC/CZN)

CC: Lt. Col. Sean Nietzke – Commander of the 86 FWS

Air Force EFH Supplemental Response Letter (August 30, 2016)

DEPARTMENT OF THE AIR FORCE
AIR FORCE CIVIL ENGINEER CENTER
JOINT BASE SAN ANTONIO LACKLAND TEXAS

AFCEC/CZN
2261 Hughes Ave., Ste. 155
JBSA Lackland, TX 78236-9853

30 August, 2016

Mr. Gerry Davis
Assistant Regional Administrator, Habitat Conservation Division
Pacific Islands Regional Office
National Marine Fisheries Service
1601 Kapiolani Blvd, Suite 1110
Honolulu, HI 96814-4700

SUBJECT: Supplemental Air Force Response to Essential Fish Habitat Conservation Recommendations for Long Range Strike Weapon Systems Evaluation Program

Dear Mr. Davis,

The Air Force appreciates the participation of you and your staff in the August 16, 2016 conference call to discuss the conservation recommendations proposed by your office on the Essential Fish Habitat (EFH) Assessment for the Long Range Strike Weapon Systems Evaluation Program (WSEP). As discussed, the Air Force will provide a summary of mission activities that occur each year from 2016 through 2021 in the form of the annual report submitted to your office. This will provide a situational awareness to the Habitat Conservation Division on the level of activities being conducted in association with Long Range Strike WSEP. For long-term activities beyond those planned for 2016, it was agreed that follow-on discussions would occur to discuss specific concerns with respect to MUS impacts.

After this conference call, the Air Force met internally with its natural resource program manager and subject matter expert to further discuss mitigation recommendations. This letter includes the Air Force's initial responses to EFH conservation recommendations and provides supplemental responses based on both discussions.

1. *Reduce, to the greatest extent practicable, the area and volume of physical and chemical impact associated with any given munitions release in the weapons impact area to minimize adverse effects to EFH and managed species.*

INITIAL RESPONSE: It is not possible for the 86 FWS to reduce the area and volume of the physical and chemical impact. Munition performance in the marine environment is one of the objectives of the weapons evaluations and therefore cannot be altered or minimized in some manner and still accomplish the operational testing objectives. Long Range Strike WSEP objectives are to evaluate maritime weapon employment data, tactics, techniques, and procedures of using weapons in an operationally realistic environment and to determine the impact of these tactics, techniques, and procedures on combat Air Force training. Any alteration would essentially change the characteristics of the weapons to something different than how the weapon would be used in real world operations and therefore would no longer meet the purpose and need of the proposed action.

SUPPLEMENTAL RESPONSE: It is understood by the Air Force that no additional explanations were needed to supplement the response to this recommendation. Reducing the area and volume of physical and chemical impacts from munitions releases would not allow the Air Force to meet its mission requirements.

2. *Locate the weapons impact area within the [Barking Sands Underwater Range Extension] BSURE to avoid any fish aggregation sites. Selection of weapons impact site needs to consider bathymetry and circulation patterns to minimize the presence of fauna. In addition, monitor the ocean surface at the weapons impact area prior to munitions release and avoid detonations if and when pelagic MUS are feeding and/or aggregations of bait are observed at the site.*

INITIAL RESPONSE: The weapon impact area is a stationary location that has been pre-determined by the 86 FWS and has been used for acoustic analyses associated with Marine Mammal Protection Act (MMPA) and Endangered Species Act (ESA) consultations. The BSURE area provides conditions that are essential for realistic military training and testing activities. The ability to use the impact area meets the purpose and need of the proposed action, and these areas have been the subject of prior consultation and approvals by NMFS under the MMPA and ESA for other Service programs. The impact point would be pre-programmed into the weapons prior to release. Relocation of the impact area during the mission due to the presence of fish aggregations that will fluctuate in location, time, and size based on varying weather and sea state conditions is therefore not operationally feasible. Pre-mission and post-mission surveys of the impact area will be conducted aerially for the presence of MMPA and ESA-listed species (marine mammals and sea turtles). If protected species are observed within the impact area, munitions would not be released until the animals are observed to have exited the impact area, or thought to have exited the impact area based on its course and speed, or the impact area has been clear of sightings for 30 minutes. The ability to identify specific pelagic MUS and/or aggregations of baitfish from an aerial platform could only be accomplished if they are at or just below the water surface and sea state conditions are favorable. However, mitigation measures implemented for the protection of marine mammals and sea turtles would have the added benefit to fish aggregations that are also present, but not visible at the surface.

SUPPLEMENTAL RESPONSE: It is understood by the Air Force that no additional explanations were needed to supplement the response to this recommendation.

3. *Implement adaptive management for example incorporate trigger points prior to the end of the 5 years of the Long Range Strike WSEP to evaluate whether the initial planned*

number of munition releases (approximately 550) can be reduced while meeting the mission needs.

INITIAL RESPONSE: The 86 FWS's mission requirement is 550 munitions releases over the 5 year operational time-period. It is possible that weapon/aircraft availability, mechanical issues, inclement weather, and other environmental conditions may preclude the 86 FWS from releasing all of the munitions proposed for release over the 5 year timeframe, and that the number of munitions releases may vary from year to year. The 86 FWS will ensure that it does not exceed the number of munition releases evaluated as part of the proposed action in any given year during the 5 year operational window.

SUPPLEMENTAL RESPONSE: The Air Force has agreed to provide a copy of annual reports of its mission activities to the Habitat Conservation Division. These reports will include a summary of mission activities associated with Long Range Strike WSEP, along with the results of the mitigation measures implemented for marine mammals and sea turtles.

4. *Continue to gather information and undertake further analysis of impact to EFH and MUS associated with munitions release in Hawaiian waters. For example, determine the percent (%) of the larval pool present in offshore Hawaiian waters predicted to be killed by the variety of explosions, also the proportion of the total larval pool this constitutes, and how this affects MUS populations. In addition evaluate the extent of marine debris associated with munitions release, and the cumulative effects of this to EFH and MUS (recent deep sea exploration in the Pacific Islands Region highlight the concern of debris accumulating on the seafloor).*

INITIAL RESPONSE: The 86 FWS currently does not have the types of resources or expertise needed to conduct these types of scientific baseline studies. Furthermore, it would not be appropriate for the 86 FWS to use appropriated funds for the purposes other than those directly associated with the 86 FWS objectives. The Air Force has used the best available science to analyze the action and prepare its National Environmental Policy Act (NEPA), EFH, MMPA, and ESA documents. If new scientific information becomes available that changes the analysis or conclusions in those documents, then the Air Force will follow appropriate regulatory processes and reinitiate consultation if necessary. As part of the NEPA process, the Air Force will include this correspondence as part of the Administrative Record and will consider it for future consultations.

SUPPLEMENTAL RESPONSE: During the conference call on August 16, 2016, it was decided that the Air Force would proceed with the limited scope of missions planned for October 2016, but that the Air Force would coordinate follow-on discussions with the National Marine Fisheries Habitat Conservation Division as the Air Force works to complete consultations for a Letter of Authorization and Programmatic Biological Opinion for 2017-2021 mission activities.

A meeting with the Air Force natural resource program manager was held shortly after the conference call between the Air Force and the Habitat Conservation Division, and several points were made with respect to this EFH conservation recommendation. In order for the Air Force to program monies to fund these types of studies, a competitive and prioritized review process is conducted to determine how to allocate the fiscal year budget. Typically this is completed approximately two years in advance, meaning programming for FY2018 will be completed and approved in FY2016. Each potential project is weighted based on various factors, with the most important factor being whether there are any legal drivers to justify the expenditure. The Air Force would like to set up a conference call with its natural resource subject matter experts to further discuss this recommendation with the Habitat Conservation Division.

5. *Implement initiatives to offset/compensate for the unavoidable impacts to water quality and MUS associated with USAF munitions release operations. Consider investments into stock enhancement programs, contributing to the marine resource management activities associated with the PMRF Integrated Natural Resources Management Plan, and undertake metal clean up and marine debris removal from shallow coral reef areas in the PMRF.*

INITIAL RESPONSE: Military expended materials associated with Long Range Strike WSEP mission activities would not be released into shallow coral reef areas or near shore habitat areas and therefore debris removal in those areas by the 86 FWS is not warranted. Furthermore, an Environmental Assessment is being prepared for this proposed action and impacts to water quality are found to be insignificant upon evaluation using the best available science about fate and transport of constituents. The PMRF Integrated Natural Resources Management Plan only covers the installation and nearshore waters adjacent to the installation, so there are no projects that relate to the marine resources analyzed under the proposed action.

SUPPLEMENTAL RESPONSE: The Air Force plans to coordinate a follow-on discussion with the Habitat Conservation Division as the Air Force works to complete consultations for 2017-2021 mission activities. In order for the Air Force to program monies to fund these types of activities, a competitive and prioritized review process is conducted to determine how to allocate the fiscal year budget. The Air Force natural resource program manager would like to discuss the nature of the stock investment programs, but feels that appropriated Air Force funding may not be authorized for such a recommendation. The Air Force would like to coordinate a follow-on discussion with the National Marine Fisheries Service Habitat Conservation Division to discuss this proposed EFH conservation recommendation further.

Sincerely,

Michael Ackerman
Program Manager
NEPA Division (AFCEC/CZN)

CC: Lt. Col. Sean Nietzke – Commander of the 86 FWS

Long Range Strike WSEP IHA Request with Cover Letter

DEPARTMENT OF THE AIR FORCE
AIR FORCE CIVIL ENGINEER CENTER
JOINT BASE SAN ANTONIO LACKLAND TEXAS

AFCEC/CZN
2261 Hughes Ave., Ste. 155
JBSA Lackland, TX 78236-9853

12 May, 2016

Ms. Jolie Harrison
Division Chief, Office of Protected Resources
National Marine Fisheries Service
1315 East-West Highway, SSMC3, Room 13805
Silver Spring, MD 20910-3226

SUBJECT: Submission of the Request for an Incidental Harassment Authorization of Marine Mammals Resulting from Long Range Strike Weapon Systems Evaluation Program

Dear Ms. Harrison,

This letter and attached document is being submitted to the National Marine Fisheries Service to request an Incidental Harassment Authorization (IHA) in accordance with Section 101(a)(5)(A) of the Marine Mammal Protection Act of 1972 (MMPA) for activities described under the Preferred Alternative in the Long Range Strike Weapon Systems Evaluation Program (WSEP) Environmental Assessment/Overseas Environmental Assessment (EA/OEA). The IHA Request analyzes potential impacts to 25 marine mammal species and associated stocks resulting from Long Range Strike WSEP mission activities proposed for 2016.

The Proposed Action would authorize the Air Force to conduct operational evaluations of long range strike weapons and other munitions at the Pacific Missile Range Facility, offshore of Kauai, Hawaii. For 2016 missions, live (explosive) munitions would be released from multiple types of operation aircraft, including bombers and fighter aircraft, within military controlled airspace over the Pacific Ocean. The weapon impact point is approximately 44 nautical miles (NM) from the shore of Kauai within the Barking Sands Underwater Range Extension area. All weapons would detonate at the water surface. Net explosive weight for live ordnance ranges from 37 to 300 pounds. The water depth at the weapon impact location is over 4,600 meters. Potential impacts to marine mammals from direct strikes, ingestion stressors, and detonation effects have been assessed.

On behalf of the 86 Fighter Weapons Squadron (86 FWS), the Air Force Civil Engineering Center is requesting small numbers of takes of two marine mammal species by Level B harassment and Level B Behavioral harassment, as defined by the MMPA. Long-term impacts to stocks and marine mammal populations are not anticipated. Adherence to the mitigation measures in Chapter 11 of the IHA Request is expected to further reduce the potential for adverse impacts on marine mammal populations and associated stocks. While the Air Force

Civil Engineering Center is facilitating all environmental documentation, the action proponent and responsible party for conducting Long Range Strike WSEP missions is the 86 FWS, therefore the IHA should be issued to the Commander of the 86 FWS, Lt. Colonel Sean Nietzke.

If you have any questions regarding this Request for an IHA or any of the proposed activities, please do not hesitate to contact either Ms. Amanda Robydek at (850) 882-8395; amanda.robydek.ctr@us.af.mil or myself at (210) 925-2741; michael.ackerman.2@us.af.mil

Sincerely,

Michael D Ackerman

Michael Ackerman
Program Manager
NEPA Division (AFCEC/CZN)

ATTACHMENT: Request for an Incidental Harassment Authorization of Marine Mammals Resulting from Long Range Strike Weapon Systems Evaluation Program

REQUEST FOR AN INCIDENTAL HARASSMENT AUTHORIZATION FOR THE INCIDENTAL TAKING OF MARINE MAMMALS RESULTING FROM LONG RANGE STRIKE WEAPON SYSTEMS EVALUATION PROGRAM AT THE PACIFIC MISSILE RANGE FACILITY AT KAUAI, HAWAII

Submitted To:

Office of Protected Resources
National Marine Fisheries Service (NMFS)
1315 East-West Highway
Silver Spring, MD 20910-3226

Submitted By:

Department of the Air Force

Revised June 2016

This page is intentionally blank.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

GLOSSARY OF ACRONYMS, ABBREVIATIONS, AND SYMBOLS

≤	less than or equal to
>	greater than
°	degrees
° N	degrees North
° S	degrees South
° W	degrees West
86 FWS	86th Fighter Weapons Squadron
AFB	Air Force Base
AFCEC	Air Force Civil Engineer Center
Air Force	U.S. Air Force
BSURE	Barking Sands Underwater Range Extension
CFR	Code of Federal Regulations
CV	coefficient of variation
D	water depth (meters)
dB	decibels
dB re 1 µPa	decibels referenced to 1 micropascal
dB re 1 µPa @ 1 m	decibels referenced to 1 micropascal at 1 meter
dB re 1 $\mu Pa^2 \cdot s$	decibels referenced to 1 micropascal-squared second
DoD	Department of Defense
DPS	distinct population segment
EA	Environmental Assessment
EA/OEA	Environmental Assessment/Overseas Environmental Assessment
EEZ	Exclusive Economic Zone
ER	Extended Range
ESA	Endangered Species Act of 1973
FTS	flight termination system
GI	gastrointestinal
GPS	Global Positioning System
HARM	High-Speed Anti-Radiation Missile
HICEAS	Hawaiian Islands Cetacean and Ecosystem Assessment
HRC	Hawaii Range Complex
Hz	hertz
IHA	Incidental Harassment Authorization
INS	internal navigation system
JASSM	Joint Air-to-Surface Stand-Off Missile
JASSM-ER	Joint Air-to-Surface Stand-Off Missile-Extended Range
JB	Joint Base
JDAM	Joint Direct Attack Munition
kg	kilograms
kHz	Kilohertz
km	kilometers
km^2	square kilometers
lb	pounds
LJDAM	Laser Joint Direct Attack Munition
LOA	Letter of Authorization
m	meters
M	animal mass based on species (kilograms)
MALD	Miniature Air Launched Decoy
MALD-J	Miniature Air Launched Decoy–Jamming
mi^2	square miles
MMPA	Marine Mammal Protection Act
MSL	mean sea level

n/a	not available
N/A	not applicable
NAS	Naval Air Station
NEW	net explosive weight
NM	nautical miles
NM^2	square nautical miles
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOTAM	Notice to Airmen
NOTMAR	Notice to Mariners
Pa·s	pascal-seconds
PMRF	Pacific Missile Range Facility
psi·msec	pounds per square inch per millisecond
PTS	permanent threshold shift
SDB	Small Diameter Bomb
SDB-I/II	Small Diameter Bomb-I/II
SDB-I/SDB-II	Small Diameter Bomb-I/Small Diameter Bomb-II
SEL	sound exposure level
SPL	sound pressure level
TM	telemetry
TNT	2,4,6-trinitrotoluene
TTS	temporary threshold shift
USC	United States Code
USFWS	U.S. Fish and Wildlife Service
W-	Warning Area
WSEP	Weapon Systems Evaluation Program

EXECUTIVE SUMMARY

With this submittal, the Air Force Civil Engineer Center (AFCEC) requests an Incidental Harassment Authorization (IHA) for the incidental taking, but not intentional taking (in the form of acoustic-related and/or pressure-related impacts), of marine mammals incidental to air-to-surface missions conducted in the Barking Sands Underwater Range Extension (BSURE) area of the Pacific Missile Range Facility (PMRF), as permitted by the Marine Mammal Protection Act (MMPA) of 1972, as amended. Air-to-surface missions consist of the activities described in the Preferred Alternative of the *Environmental Assessment/Overseas Environmental Assessment (EA/OEA) for the Long Range Strike Weapon Systems Evaluation Program* (WSEP), and presented in Section 1 of this document. The purpose of the Proposed Action is to authorize the Air Force to conduct operational evaluations of long range strike weapons and other munitions as part of Long Range Strike WSEP operations. The need for the Proposed Action is to properly train units to execute requirements within Designed Operational Capability Statements, which describe units' real-world operational expectations in a time of war.

The missions may expose marine mammals in the BSURE area to sound exposure levels associated with Level B harassment (TTS and Behavioral) only. Sound and pressure metrics associated with exploding ordnance were determined to be the only activities with potential for significant impacts to marine species, as analyzed in the associated EA/OEA. Long Range Strike WSEP missions involve the use of multiple types of live and inert munitions (bombs and missiles) scored at the water surface in the BSURE. The ordnance may be delivered by multiple types of aircraft, including bombers and fighter aircraft. Weapon performance will be evaluated by an underwater acoustic hydrophone array system as the weapons strike the water surface. Net explosive weight of the live munitions ranges from 37 to 300 pounds and all detonations will occur at the water surface. Missions will occur during summer 2016. All missions will be conducted during daylight hours. The Long Range Strike WSEP impact area is approximately 44 nautical miles (81 kilometers) offshore of Kauai, Hawaii, in a water depth of about 15,240 feet (4,645 meters).

The potential takes outlined in Section 6 represent the maximum expected number of animals that could be affected. Mitigation measures will be employed to decrease the number of animals potentially affected, particularly within the mortality and Level A harassment zones. Using the most applicable density estimates for each species, the zone of influence for each detonation event, an estimate of the potential number of animals exposed to acoustic and/or pressure thresholds was analyzed using the most recent criteria and thresholds (Finneran and Jenkins, 2012). No marine mammals would be exposed to impulse pressure levels associated with mortality and no marine mammals would be exposed to injurious slight lung injury or GI tract injury. Without mitigation measures in place, a maximum of approximately 1 dwarf sperm whale could potentially be exposed to injurious (permanent threshold shift [PTS]) Level A Harassment; 9 dwarf sperm whales and 3 pygmy sperm whales could potentially be exposed to non-injurious (temporary threshold shift [TTS]) Level B harassment. Approximately 64 dwarf sperm whales and 26 pygmy sperm whales could potentially be exposed to noise corresponding to the Level B behavioral harassment threshold. These exposure estimates do not take into account the mitigation measures identified in Section 11, which may reduce the potential for impacts.

Marine mammals potentially affected by Long Range Strike WSEP mission activities in the BSURE area include a total of 25 species and 27 stocks of whales, dolphins, and the Hawaiian monk seal (*Neomonachus schauinslandi*).

The information and analyses provided in this application are presented to fulfill the permit request requirements of Title I, Sections 101(a)(5)(A) and 101(a)(5)(F) of the MMPA.

This page is intentionally blank.

1.0 DESCRIPTION OF ACTIVITIES

1.1 INTRODUCTION

Due to threats to national security, increased missions involving air-to-surface activities have been directed by the Department of Defense (DoD). Accordingly, the U.S. Air Force (Air Force) seeks the ability to conduct operational evaluations of all phases of long range strike weapons within the U.S. Navy's Hawaii Range Complex (HRC). The actions would fulfill the Air Force's requirement to evaluate full-scale maneuvers for such weapons, including scoring capabilities under operationally realistic scenarios.

In this document, which evaluates only missions proposed for 2016, air-to-surface activities refer to the deployment of live (containing explosive charges) missiles from aircraft toward the water surface. All detonations would occur at the water surface. Evaluations conducted in future years of the program (2017 to 2021) would involve expanded mission scenarios, including additional types of bombs and missiles, use of inert (containing no explosives) weapons, and detonations occurring in the air and slightly below the water surface. However, the Air Force will evaluate those activities in a separate request for a Letter of Authorization (LOA). This document is limited to analysis of a total of nine missile and bomb releases that involve detonations at the water surface. The Air Force is preparing an Environmental Assessment/Overseas Environmental Assessment (EA/OEA) to evaluate all components of the proposed activities. The activities described below in Section 1.2, *Mission Description*, represent the preferred alternative of the EA/OEA.

The Proposed Action would take place in the Barking Sands Underwater Range Extension (BSURE) area of the Pacific Missile Range Facility (PMRF), offshore of Kauai, Hawaii. Missions are planned to begin in summer 2016 and continue for the following five years. The 86th Fighter Weapons Squadron (86 FWS) is the test execution organization under the 53rd Wing for all Weapon Systems Evaluation Program (WSEP) deployments. WSEP objectives are to evaluate air-to-surface and maritime weapon employment data, evaluate tactics, techniques, and procedures in an operationally realistic environment, and to determine the impact of tactics, techniques, and procedures on combat Air Force training. The munitions associated with the proposed activities are not part of a typical unit's training allocations, and prior to attending a WSEP evaluation, most pilots and weapon systems officers have only dropped weapons in simulators or used the aircraft's simulation mode. Without WSEP operations, pilots would be using these weapons for the first time in combat. On average, half of the participants in each unit drop an actual weapon for the first time during a WSEP evaluation. Consequently, WSEP is a military readiness activity and is the last opportunity for squadrons to receive operational training and evaluations before they deploy.

This document has been prepared in accordance with the applicable regulations of the Marine Mammal Protection Act (MMPA) of 1972, as amended by the National Defense Authorization Act for Fiscal Year 2004 (Public Law 108-136) and its implementing regulations. The Incidental Harassment Authorization (IHA) request is based on: (1) the analysis of spatial and temporal distributions of marine mammals in the BSURE area (also referred to as the Study Area), (2) the review of testing activities that have the potential to incidentally take marine mammals, and (3) a technical risk assessment to determine the likelihood of effects. This chapter describes those activities that are likely to result in Level B harassment under the MMPA.

1.2 MISSION DESCRIPTION

This section describes the Long Range Strike WSEP missions to be conducted by the Air Force in the BSURE area of the PMRF (see Section 2, *Duration and Location of the Activities*, for a description of the Study Area). The actions include air-to-surface test missions of the Joint Air-to-Surface Stand-off Missile

(JASSM) and the Small Diameter Bomb-I/II (SDB-I/II) including detonations at the water surface. The following subsections describe aircraft operations, weapons used, schedule, and typical mission procedures.

Aircraft Operations

Aircraft used for munition releases would include bombers and fighter aircraft. Additional airborne assets, such as the P-3 Orion or the P-8 Poseidon, would be used to relay telemetry (TM) and flight termination system (FTS) streams between the weapon and ground stations. Other support aircraft would be associated with range clearance activities before and during the mission and with air-to-air refueling operations. All weapon delivery aircraft would originate from an out base and fly into military-controlled airspace prior to employment. Due to long transit times between the out base and mission location, air-to-air refueling may be conducted in either Warning Area 188 (W-188) or W-189. Bombers, such as the B-1, would deliver the weapons, conduct air-to-air refueling, and return to their originating base as part of one sortie. However, when fighter aircraft are used, the distance and corresponding transit time to the various potential originating bases would make return flights after each mission day impractical. In these cases, the aircraft would temporarily (less than one week) park overnight at Hickam Air Force Base (AFB) and would return to their home base at the conclusion of each mission set. Multiple weapon-release aircraft would be used during some missions, each potentially releasing multiple munitions. The Long Range Strike WSEP missions scheduled for 2016 are proposed to occur in one day, with the following day reserved as a back-up day. Approximately 10 Air Force personnel would be on temporary duty to support the mission. Table 1-1 summarizes example types of aircraft proposed to support Long Range Strike WSEP missions.

Table 1-1. Summary of Example Aircraft Usage During Long Range Strike WSEP Missions

Type	Example Aircraft	Purpose	Potential Outbases
Bombers	B-1, B-2, B-52	Weapon release	Ellsworth AFB; Dyess AFB; Barksdale AFB; Whiteman AFB; Minot AFB
Fighter aircraft	F-15, F-16, F-22, F-35	Weapon release, chase aircraft, range clearance	Mountain Home AFB; Nellis AFB; Hill AFB; JB Hickam-Pearl Harbor JB Elmendorf-Richardson; JB Langley-Eustis
Refueling tankers	KC-135	Air-to-air refueling	McConnell, AFB
Surveillance	P-3, P-8	TM and FTS relays	Pt. Mugu, NAS
Helicopters	S-61N	Range clearance, protected species surveys	PMRF
Cargo aircraft	C-130, C-26	Range clearance, protected species surveys	U.S. Coast Guard; PMRF

AFB = Air Force Base; FTS = flight termination system; JB = Joint Base; NAS = Naval Air Station; PMRF = Pacific Missile Range Facility; TM = telemetry

Aircraft flight maneuver operations and weapon release would be conducted in W-188A. Chase aircraft may be used to evaluate weapon release and to track weapons. Flight operations and weapons delivery would be in accordance with published Air Force directives and weapon operational release parameters, as well as all applicable Navy safety regulations and criteria established specifically for PMRF. Aircraft supporting Long Range Strike WSEP missions would primarily operate at high altitudes—only flying below 3,000 feet for a limited time as needed for escorting non-military vessels outside the hazard area or for monitoring the area for protected marine species (e.g., marine mammals, sea turtles). Protected marine species aerial surveys would be temporary and would focus on an area surrounding the weapon impact point on the water. Post-mission surveys would focus on the area down current of the weapon impact location. A detailed description of protected marine species clearance procedures is included in Section 11. Range clearance procedures for each mission would cover a much larger area for human safety. Weapon release parameters would be conducted as approved by PMRF Range Safety. Daily mission briefs would specify planned release conditions for each mission. Aircraft and weapons would be tracked for time, space, and position information. The 86 FWS test director would coordinate with the PMRF Range Safety Officer, Operations Conductor, Range Facility Control Officer, and other applicable mission control personnel for aircraft control, range clearance, and mission safety. Figure 1-1 shows a photograph taken from a chase aircraft of a JASSM being released and in flight.

Figure 1-1. Joint Air-to-Surface Stand-Off Missile (JASSM) Released

Weapons Descriptions

Joint Air-to-Surface Stand-off Missile/Joint Air-to-Surface Stand-Off Missile-Extended Range (JASSM/JASSM-ER)

The JASSM (Figure 1-2) is a stealthy precision cruise missile designed for launch outside area defenses against hardened, medium-hardened, soft, and area type targets. The JASSM has a range of more than 200 nautical miles (NM) (370 kilometers [km]) and carries a 1,000-pound warhead with approximately 300 pounds of 2,4,6-trinitrotoluene (TNT) equivalent net explosive weight (NEW). The specific explosive used is AFX-757, a type of plastic bonded explosive (PBX). The weapon has the capability to fly a preprogrammed route from launch to a target, using Global Positioning System (GPS) technology and an internal navigation system (INS) combined with a Terminal Area Model when available. Additionally, the weapon has a Common Low Observable Auto-Routing function that gives the weapon the ability to find the route that best utilizes the low observable qualities of the JASSM. In either case, these routes can be modeled prior to weapon release. The JASSM-ER has additional fuel and a different engine for a greater range than the JASSM (500 NM [926 km]) but maintains the same functionality of the JASSM.

Figure 1-2. Joint Air-to-Surface Stand-Off Missile (JASSM)

Small Diameter Bomb-I/Small Diameter Bomb-II (SDB-I/SDB-II)

The SDB I (Figure 1-3) is a 250-pound air-launched GPS-INS guided weapon for fixed soft to hardened targets. SDB II (Figure 1-4) expands the SDB I capability with network enabling and uses a tri-mode sensor infrared, millimeter, and semi-active laser to attack both fixed and movable targets. Both munitions have a range of up to 60 NM (111 km). The SDB-I contains 37 pounds of TNT-equivalent NEW, and the SDB-II contains 23 pounds NEW. The explosive used in both SDB-I and SDB-II is AFX-757.

Figure 1-3. Small Diameter Bomb-I (SDB-I)

Figure 1-4. Small Diameter Bomb-II (SDB-II)

Schedule and General Mission Procedures

Initial phases of the Long Range Strike WSEP operational evaluations are proposed for September 2016 and would consist of releasing only one live JASSM/JASSM-ER and up to eight SDBs in military controlled airspace. Immediate evaluations for JASSM/JASSM-ER and SDB I are needed; therefore, they are the only munitions being proposed for summer 2016 missions. Weapon release parameters for 2016 missions would involve a B-1 bomber releasing one live JASSM and fighter aircraft, such as F-15, F-16, or F-22, releasing live SDB-I. Up to four SDB-I munitions would be released simultaneously, similar to a ripple effect, each hitting the water surface within a few seconds of each other; however the SDB-I releases would occur separate from the JASSM. All releases would occur on the same mission day.

Follow-on years (2017–2021) would add evaluations of High-Speed Anti-Radiation Missile (HARM), Joint Direct Attack Munition/Laser Joint Direct Attack Munition (JDAM/LJDAM), and Miniature Air Launched Decoy/Miniature Air Launched Decoy–Jamming (MALD/MALD-J) munitions, in addition to continued evaluations of JASSM/JASSM-ER and SDB I/II. Similar to what is proposed for 2016 missions, up to four SDB I/II munitions could be released simultaneously, such that each ordnance would hit the water surface within a few seconds of each other. It is not known how many weapon releases or what combination of munitions would be released each day. However, aside from the SDB-I/II releases, all other weapons would be released separately, impacting the water surface at different times. As discussed in Section 1.1, *Introduction*, these follow-on actions are evaluated in a separate LOA request, and activities included in this IHA request are restricted to one JASSM/JASSM-ER and up to eight SDB-I releases involving surface detonations only.

A typical mission day would consist of pre-mission checks, safety review, crew briefings, weather checks, clearing airspace, range clearance, mitigations/monitoring efforts, and other military protocols prior to launch of weapons. Potential delays could be the result of multiple factors including, but not limited to, adverse weather conditions leading to unsafe take-off, landing, and aircraft operations, inability to clear the range of non-mission vessels or aircraft, mechanical issues with mission aircraft or munitions, or presence of protected species in the impact area. If the mission is cancelled due to any of these, one back-up day has also been scheduled as a contingency. These standard operating procedures are usually done in the morning, and live range time may begin in late morning once all checks are complete and approval is granted from range control. The range would be closed to the public for a maximum of four hours per mission day.

Each long range strike weapon would be released in W-188A and would follow a given flight path with programmed GPS waypoints to mark its course in the air. Long range strike weapons would complete their maximum flight range (up to 500-NM distance for JASSM-ER) at an altitude of approximately 18,000 feet mean sea level (MSL) and terminate at a specified location for scoring of the impact. The cruise time would vary among the munitions, but would be about 45 minutes for JASSM/JASSM-ER and 10 minutes for SDB-I/II. The time frame between employments of successive munitions would vary, but releases could be spaced by approximately one hour to account for the JASSM cruise time. The routes and associated safety profiles would be contained within W-188A boundaries. The objective of the route designs is to complete full-scale evasive maneuvers that avoid simulated threats and would, therefore, not consist of a standard “paper clip” or regularly shaped route. The final impact point on the water surface would be programmed into the munitions for weapons scoring and evaluations.

All missions would be conducted in accordance with applicable flight safety, hazard area, and launch parameter requirements established for PMRF. A weapon hazard region would be established, with the size and shape determined by the maximum distance a weapon could travel in any direction during its descent. The hazard area is typically adjusted for potential wind speed and direction, resulting in a maximum composite safety footprint for each mission (each footprint boundary is at least 10 NM from the Kauai coastline). This information is used to establish a human safety area which must be verified to be clear of all non-mission and non-essential vessels and aircraft before live weapons are released. In addition, a buffer area must also be cleared so that vessels do not enter the human safety area during the launch window. At the time of writing this IHA Request, the size of the human safety area had not been calculated by PMRF Range Safety Personnel. These calculations are typically completed a few weeks before missions begin. Prior to weapon release, a range sweep of the human safety area would be conducted by participating mission aircraft or other appropriate aircraft, potentially including S-61N helicopter, C-26 aircraft, fighter aircraft (F-15E, F-16, F-22), or the Coast Guard’s C-130 aircraft.

PMRF has used small water craft docked at the Port Allen public pier to keep nearshore areas clear of tour boats for some mission launch areas. However, for missions with large hazard areas that occur far offshore from Kauai, it would be impractical for these smaller vessels to conduct range clearance activities. The composite safety footprint weapons associated with Long Range Strike WSEP missions is anticipated to be rather large; therefore, it is likely that range clearing activities would be conducted solely by aircraft.

The Range Facility Control Officer is responsible for establishing hazard clearance areas, directing clearance and surveillance assets, and reporting range status to the Operations Conductor. The Control

Officer is also responsible for submitting all Notice to Airmen (NOTAMs) and Notice to Mariners (NOTMARs), and for requesting all Federal Aviation Administration airspace clearances. In addition to the human safety measures described above, protected species surveys are carried out before and after missions, as summarized in Section 11.

Table 1-2 summarizes munition and mission information for activities scheduled to occur in September 2016.

Table 1-2. Summary of Proposed Testing at Pacific Missile Range Facility in 2016

Munition	Fusing Option	NEW (lb)	Detonation Scenario	Annual Total Number of Munitions
JASSM/JASSM-ER	Live/Instantaneous	300	Surface	1
SDB-I	Live/Instantaneous	37	Surface	8

ER = Extended Range; JASSM = Joint Air-to-Surface Stand-off Missile; lb = pounds; NEW = net explosive weight; SDB = Small Diameter Bomb

2.0 DURATION AND LOCATION OF THE ACTIVITIES

Long Range Strike WSEP missions are scheduled to occur during September 2016. Missions would occur on a weekday, during daytime hours only, with a maximum of one JASSM/JASSM-ER and eight SDBs released. All activities will take place within the PMRF, which is located in Hawaii on and off the western shores of the island of Kauai and includes broad ocean areas to the north, south, and west (Figure 2-1). However, there would be no ground-based or nearshore activities requiring the use of any shoreline areas of Kauai; all aspects and associated impacts from Long Range Strike WSEP missions would occur over open ocean areas. PMRF, as part of the Navy's HRC, is a Major Range and Test Facility Base and, as such, supports the full spectrum of DoD test and evaluation requirements. PMRF is also the world's largest instrumented, multi-environment military testing and training range capable of supporting subsurface, surface, air, and space operations. The PMRF includes 1,020 square nautical miles (NM^2) of instrumented ocean areas at depths between 1,800 feet (549 meters [m]) and 15,000 feet (4,572 m), 42,000 NM^2 of controlled airspace, and a temporary operating area covering 2.1 million NM^2 of ocean area.

Within the PMRF, activities would occur in the BSURE area, which lies in W-188. The specific impact location within the BSURE area, which is the central point around which all missions are expected to occur, is shown on Figure 2-2. The BSURE consists of about 900 NM^2 of instrumented underwater ranges, encompassing the deepwater portion of the PMRF and providing over 80 percent of PMRF's underwater scoring capability. The BSURE facilitates training, tactics, development, and test and evaluation for air, surface, and subsurface weapons systems in deep water. It provides a full spectrum of range support, including radar, underwater instrumentation, telemetry, electronic warfare, remote target command and control, communications, data display and processing, and target/weapon launching and recovery facilities. The underwater tracking system begins 9 NM (17 km) from the north shore of Kauai and extends out to 40 NM (74 km) from shore. Long Range Strike WSEP missions would employ live weapons with long flight paths requiring large amounts of airspace and conclude with weapon impact and surface detonations within the BSURE instrumented range.

Figure 2-1. Regional Location of Long Range Strike WSEP Activities

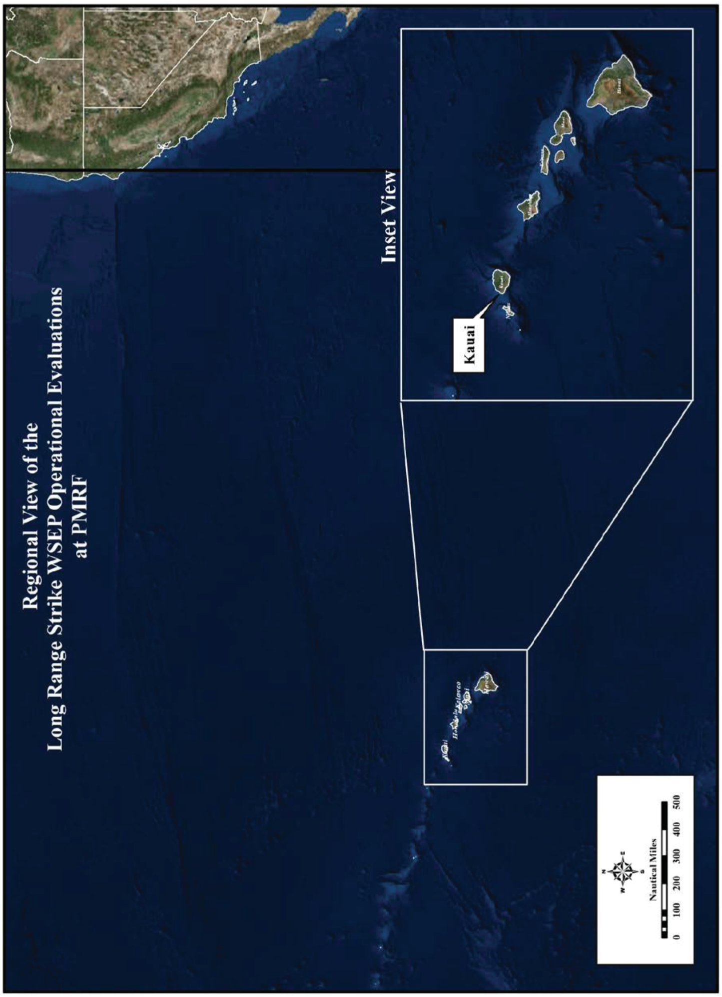
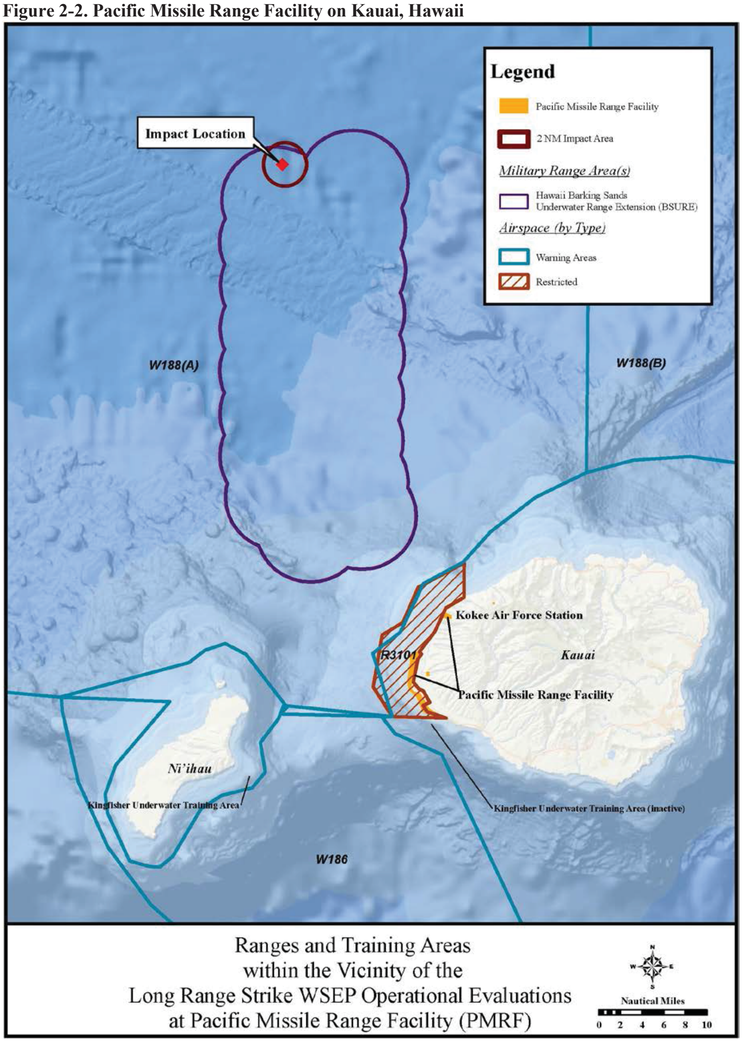


Figure 2-2. Pacific Missile Range Facility on Kauai, Hawaii



3.0 MARINE MAMMAL SPECIES AND NUMBERS

This section identifies marine mammal species and stocks potentially found in the PMRF (including the BSURE area), provides general information on marine mammal behavior, hearing and vocalization, and threats, and provides a density estimate for each species. Marine mammals are a diverse group of approximately 130 species that rely wholly or substantially on the sea for important life functions and include cetaceans (whales, dolphins, and porpoises), pinnipeds (seals, sea lions, and walruses), sirenians (manatees, dugongs, and sea cows), marine otters, and polar bears. Of these animal groups, whales, dolphins, and one pinniped occur in the Study Area. Although most marine mammal species live wholly or predominantly in the marine habitat, some spend time in terrestrial habitats (e.g., seals) or freshwater environments (e.g., freshwater dolphins). All marine mammals in the United States are protected under the MMPA; some species are additionally protected under the Endangered Species Act of 1973 (ESA). Marine mammals may be designated under the ESA as endangered, threatened, candidate, or proposed species. Under the MMPA, species may be designated as depleted, which is defined as a species or stock that is (1) below its optimum sustainable population or (2) designated as endangered or threatened under the ESA. Marine mammal species protected under the ESA are evaluated separately in an associated Biological Assessment.

Cetaceans may be categorized as odontocetes or mysticetes. Odontocetes, which range in size from about 1 m to over 18 m, have teeth that are used to capture and consume individual prey. Mysticetes, which are also known as baleen whales, range in size from about 10 m to over 30 m. Instead of teeth, mysticetes have baleen (a fibrous structure made of keratin) in their mouth which is used to filter the large numbers of small prey that are engulfed, sucked, or skimmed from the water or ocean floor sediments. Cetaceans inhabit virtually every marine environment, from coastal waters to the open ocean. Their distribution is primarily influenced by prey availability, which depends on factors such as ocean current patterns, bottom relief, and sea surface temperature, among others. Most of the large cetaceans are migratory, but many small cetaceans do not migrate in the strictest sense. Instead, they may undergo seasonal dispersal, or shifts in density. Pinnipeds generally spend a large portion of time on land at haulout sites used for resting and moulting, and at rookeries used for breeding and nursing young, and return to the water to forage. The only pinniped species that occurs regularly in Hawaii is the Hawaiian monk seal (*Neomonachus schauinslandi*). In the Main Hawaiian Islands, they are generally solitary and have no established rookeries.

Marine mammals with potential occurrence in the BSURE area are shown in Table 3-1.

Table 3-1. Marine Mammals with Potential Occurrence in the Study Area

Common Name	Scientific Name
Mysticetes (baleen whales)	
Humpback whale	*Megaptera novaeangliae*
Blue whale	*Balaenoptera musculus*
Fin whale	*Balaenoptera physalus*
Sei whale	*Balaenoptera borealis*
Bryde's whale	*Balaenoptera brydei/edeni*
Minke whale	*Balaenoptera acutorostrata*
Odontocetes (toothed whales and dolphins)	
Sperm whale	*Physeter macrocephalus*
Pygmy sperm whale	*Kogia breviceps*
Dwarf sperm whale	*Kogia sima*
Killer whale	*Orcinus orca*
False killer whale	*Pseudorca crassidens*
Pygmy killer whale	*Feresa attenuata*
Short-finned pilot whale	*Globicephala macrorhynchus*

Common Name	Scientific Name
Melon-headed whale	*Peponocephala electra*
Bottlenose dolphin	*Tursiops truncatus*
Pantropical spotted dolphin	*Stenella attenuata*
Striped dolphin	*Stenella coeruleoalba*
Spinner dolphin	*Stenella longirostris*
Rough-toothed dolphin	*Steno bredanensis*
Fraser's dolphin	*Lagenodelphis hosei*
Risso's dolphin	*Grampus griseus*
Cuvier's beaked whale	*Ziphius cavirostris*
Blainville's beaked whale	*Mesoplodon densirostris*
Longman's beaked whale	*Indopacetus pacificus*
Pinnipeds	
Hawaiian monk seal	*Neomonachus schauinslandi*

General Behavior

Many species of marine mammals, particularly odontocetes, are highly social animals that spend much of their lives living in groups or schools ranging from several individuals to several thousand individuals. Aggregations of baleen whales may form during particular breeding or foraging seasons, although they do not appear to persist over time as a social unit. All marine mammals dive beneath the water surface, primarily for the purpose of foraging. Dive frequency and the time spent during dives vary among species and within individuals of the same species. Some species that forage on deep-water prey can make dives lasting over an hour. Other species spend the majority of their lives close to the surface and make relatively shallow dives. The diving behavior of a particular species or individual has implications regarding the ability to detect them during mitigation and monitoring activities. In addition, their distribution through the water column is an important consideration when conducting acoustic exposure analyses.

Vocalization and Hearing

All marine mammals that have been studied can produce sounds and use sounds to forage, orient, detect and respond to predators, and socially interact with others. Measurements of marine mammal sound production and hearing capabilities provide some basis for assessment of whether exposure to a particular sound source may affect a marine mammal. Marine mammal hearing abilities are quantified using live animals either via behavioral audiometry or electrophysiology. Behavioral audiograms are plots of animals' exhibited hearing threshold versus frequency, and are obtained from captive, trained live animals. Behavioral audiograms are difficult to obtain because many species are too large, too rare, and too difficult to acquire and maintain for experiments in captivity. Electrophysiological audiometry measures small electrical voltages produced by neural activity when the auditory system is stimulated by sound. The technique is relatively fast, does not require a conscious response, and is routinely used to assess the hearing of newborn humans. Understanding of a species' hearing ability may be based on the behavioral audiogram of only a single individual or small group of animals. In addition, captive animals may be exposed to local ambient sounds and other environmental factors that may impact their hearing abilities and may not accurately reflect the hearing abilities of free-swimming animals (Houser et al., 2010b). For animals not available in captive or stranded settings (including large whales and rare species), estimates of hearing capabilities are made based on physiological structures, vocal characteristics, and extrapolations from related species.

Direct measurement of hearing sensitivity exists for only about 25 of the nearly 130 species of marine mammals. Table 3-2 provides a summary of sound production and general hearing capabilities for marine mammals with potential occurrence in the Study Area. For purposes of the analyses in this document, marine mammals are arranged into the following functional hearing groups based on their generalized hearing sensitivities: high-frequency cetaceans, mid-frequency cetaceans, low-frequency cetaceans (mysticetes), and phocid pinnipeds (true seals). Summaries of the functional hearing groups applicable to this document are provided below. For a detailed discussion of all marine mammal functional hearing groups and their derivation, see Finneran and Jenkins (2012).

Table 3-2. Hearing and Vocalization Ranges for Marine Mammal Functional Hearing Groups and Species Potentially Occurring within the Study Area

Functional Hearing Group	Species Potentially Present in the Study Area	Sound Production		General Hearing Ability Frequency Range
		Frequency Range	Source Level (dB re 1 µPa @ 1 m)	
High-Frequency Cetaceans	Kogia Species (Dwarf Sperm Whale and Pygmy Sperm Whale)	100 Hz to 200 kHz	120 to 205	200 Hz to 180 kHz
Mid-Frequency Cetaceans	Sperm Whale, Beaked Whales (*Indopacetus*, *Mesoplodon*, and *Ziphius* species), Bottlenose Dolphin, Fraser's Dolphin, Killer Whale, False Killer Whale, Pygmy Killer Whale, Melon-headed Whale, Short-finned Pilot Whale, Risso's Dolphin, Rough-toothed Dolphin, Spinner Dolphin, Pantropical Spotted Dolphin, Striped Dolphin	100 Hz to >100kHz	118 to 236	150 Hz to 160 kHz
Low-Frequency Cetaceans	Blue Whale, Bryde's Whale, Fin Whale, Humpback Whale, Minke Whale, Sei Whale	10 Hz to 20 kHz	129 to 195	7 Hz to 22 kHz
Phocidae	Hawaiian monk seal	100 Hz to 12 kHz	103 to 180	In water: 75 Hz to 75 kHz

> = greater than; dB re 1 µPa @ 1 m = decibels referenced to 1 microPascal at 1 meter; Hz = hertz; kHz = kilohertz

High-Frequency Cetaceans. Marine mammals within the high-frequency cetacean functional hearing group are all odontocetes (toothed whales) and includes eight species and subspecies of porpoises (family: Phocoenidae); dwarf and pygmy sperm whales (family: Kogiidae); six species and subspecies of river dolphins; and four species of Cephalorhynchus. The only high-frequency cetaceans found in the Study Area are dwarf sperm whale and pygmy sperm whale. Functional hearing in high-frequency cetaceans occurs between approximately 200 hertz (Hz) and 180 kilohertz (kHz) (Southall et al., 2007).

Sounds produced by high-frequency cetaceans range from approximately 100 Hz to 200 kHz with source levels of 120 to 205 decibels (dB) referenced to (re) 1 micro (µ) Pascal (Pa) at 1 m (Madsen et al., 2005; Richardson et al., 1995; Verboom and Kastelein, 2003; Villadsgaard et al., 2007). Recordings of sounds produced by dwarf and pygmy sperm whales consist almost entirely of the click/pulse type (Marten, 2000). High-frequency cetaceans also generate specialized clicks used in biosonar (echolocation) at frequencies above 100 kHz that are used to detect, localize, and characterize underwater objects such as prey (Richardson et al., 1995).

An electrophysiological audiometry measurement on a stranded pygmy sperm whale indicated best sensitivity between 90 to 150 kHz (Ridgway and Carder, 2001).

Mid-Frequency Cetaceans. Marine mammals within the mid-frequency cetacean functional hearing group are all odontocetes, and include the sperm whale (family: Phystereidae); 32 species and subspecies of dolphins (family: Delpinidae); the beluga and narwhal (family: Monodontidae); and 19 species of beaked and bottlenose whales (family: Ziphiidae). The following members of the mid-frequency cetacean group are present or have a reasonable likelihood of being present in the Study Area: sperm whale, killer whale, false killer whale, pygmy killer whale, short-finned pilot whale, melon-headed whale, common bottlenose dolphin, pantropical spotted dolphin, striped dolphin, spinner dolphin, rough-toothed dolphin, Fraser's dolphin, Risso's dolphin, and beaked whales (*Berardius, Indopacetus, Mesoplodon*, and *Ziphius* species). Functional hearing in mid-frequency cetaceans is conservatively estimated to be between approximately 150 Hz and 160 kHz (Southall et al., 2007).

Hearing studies on cetaceans have focused primarily on odontocete species, and hearing sensitivity has been directly measured for a number of mid-frequency cetaceans including Atlantic white-sided dolphins (*Lagenorhynchus acutus*) (Houser et al., 2010a), common dolphins (*Delphinus* spp.) (Houser et al., 2010a), Atlantic bottlenose dolphins (Johnson ,1967), belugas (White et al., 1977; Finneran et al., 2005), Indo-Pacific bottlenose dolphins (Houser et al., 2010a), Black Sea bottlenose dolphins (Popov et al., 2007), striped dolphins (Kastelein et al., 2003), white-beaked dolphins (Nachtigall et al., 2008), Risso's dolphins (Nachtigall et al., 2005), belugas (*Delphinapterus leucas*) (Finneran et al. 2005; White et al. 1977), false killer whales (Yuen et al. 2005), killer whales (Szymanski et al., 1999), Gervais' beaked whales (Finneran and Schlundt, 2009), and Blainville's beaked whales (Pacini et al., 2011). All audiograms exhibit the same general U-shape, with a wide nominal hearing range between approximately 150 Hz and 160 kHz.

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

Low-Frequency Cetaceans. Marine mammals within the low-frequency functional hearing group are all mysticetes. This group is comprised of 13 species and subspecies of mysticete whales in six genera: *Eubalaena, Balaena, Caperea*, *Eschrichtius, Megaptera*, and *Balaenoptera*. The following members of the low-frequency cetacean group are present or have a reasonable likelihood of being present in the Study Area: humpback, blue, fin, sei, Bryde's, and minke whales. Functional hearing in low-frequency cetaceans is conservatively estimated to be between approximately 7 Hz and 22 kHz (Southall et al., 2007).

Because of animal size and availability of live specimens, direct measurements of mysticete whale hearing are unavailable, although there was one effort to measure hearing thresholds in a stranded grey whale (Ridgway and Carder, 2001). Because hearing ability has not been directly measured in these species, it is inferred from vocalizations, ear structure, and field observations. Vocalizations are audible somewhere in the frequency range of production, but the exact range cannot be inferred (Southall et al., 2007).

Mysticete cetaceans produce low-frequency sounds that range in the tens of Hz to several kHz that most likely serve social functions such as reproduction, but may have an orientation function as well (Green et al., 1994). Humpback whales are the notable exception within the mysticetes, with some calls exceeding

10 kHz. These sounds can be generally categorized as low-frequency moans; bursts or pulses; or more complex songs (Edds-Walton, 1997; Ketten, 1997). Source levels of most mysticete sounds range from 150–190 dB re 1 µPa (see Richardson et al., 1995).

Phocid Pinnepeds. The only phocid (true seal) present in the Study Area is the Hawaiian monk seal. Hearing in phocids has been tested in the following species: gray seals (Ridgway et al., 1975); harbor seals (Richardson et al., 1995; Terhune and Turnbull, 1995; Kastak and Schusterman, 1998; Wolski et al., 2003; Southall et al., 2007; Kastelein et al., 2012a); harp seals (Terhune and Ronald, 1971; Terhune and Ronald, 1972); Hawaiian monk seals (Thomas et al., 1990b); northern elephant seal (Kastak and Schusterman, 1998; Kastak and Schusterman, 1999); and ringed seals (Terhune and Ronald, 1975; Terhune and Ronald, 1976). Phocid hearing limits are estimated to be 75 Hz–30 kHz in air and 75 Hz–75 kHz in water (Kastak and Schusterman, 1999; Kastelein et al., 2009a; Kastelein et al., 2009b; Møhl, 1968; Reichmuth, 2008; Terhune and Ronald, 1971; Terhune and Ronald, 1972).

General Threats

Marine mammal populations can be influenced by various factors and human activities. These factors can affect marine mammal populations directly (e.g., hunting and whale watching), or indirectly (e.g., reduced prey availability or lowered reproductive success). Marine mammals may also be influenced by natural phenomena such as storms and other extreme weather patterns, and climate change. Generally, not much is known about how large storms and other weather patterns affect marine mammals, other than that mass strandings (when two or more marine mammals become beached or stuck in shallow water) sometimes coincide with hurricanes, typhoons, and other tropical storms (Marsh, 1989; Rosel and Watts, 2008). Climate change can potentially affect marine mammal species directly through habitat loss (especially for species that depend on ice or terrestrial areas) and indirectly via impacts on prey, changing prey distributions and locations, and changes in water temperature.

Mass die offs of some marine mammal species have been linked to toxic algal blooms. In such cases, the mammals consume prey that has consumed toxic plankton. All marine mammals have parasites that, under normal circumstances, probably do little overall harm, but that under certain conditions can cause health problems or even death (Jepson et al., 2005; Bull et al., 2006; Fauquier et al., 2009). Disease affects some individuals (especially older animals), and occasionally disease epidemics can injure or kill a large percentage of a population (Paniz-Mondolfi and Sander-Hoffmann, 2009; Keck et al., 2010). Recently the first case of morbillivirus in the central Pacific was documented for a stranded Longman's beaked whale at Maui (West et al., 2012).

Human impacts on marine mammals have received much attention in recent decades and include hunting (both commercial and native practices), fisheries interactions (such as gear entanglement or shootings by fishers), bycatch (accidental or incidental catch), indirect effects of fisheries through takes of prey species, ship strikes, noise pollution, chemical pollution, and general habitat deterioration or destruction. Direct hunting, as in whaling and sealing operations, provided the original impetus for marine mammal management efforts and has driven much of the early research on cetaceans and pinnipeds (Twiss and Reeves, 1999). In 1994, the MMPA was amended to formally address bycatch. Cetacean bycatch subsequently declined by 85 percent between 1994 and 2006. However, fishery bycatch is likely the most impactful problem presently and may account for the deaths of more marine mammals than any other cause (Northridge, 2008; Read, 2008; Hamer et al., 2010; Geijer and Read, 2013). For example, bycatch has significantly contributed to the decline of the Hawaiian population of false killer whales (Boggs et al., 2010).

Ship strikes are an issue of increasing concern for most marine mammals, particularly baleen whale species. There were nine reported ship collisions with humpback whales in the Hawaiian Islands in 2006 (none involved Navy vessels), as recorded by the National Marine Fisheries Service (NMFS) Pacific Islands Region Marine Mammal Response Network Activity Updates (NMFS, 2007a). Overall, from

2007 to 2012 in Hawaii, there were 39 vessel collisions involving humpback whales (Bradford and Lyman, 2015). None of these strikes involved Navy vessels. A humpback carcass was discovered on the shore of southwest Molokai in 2010 with indications that the death resulted from trauma consistent with a ship strike (NMFS, 2010e). Chemical pollution is also of concern, although for the most part, its effects on marine mammals are not well understood (Aguilar de Soto et al., 2008). Chemical pollutants found in pesticides flow into the marine environment from human use on land and are absorbed into the bodies of marine mammals, accumulating in their blubber or internal organs, or are transferred to the young from its mother's milk (Fair et al., 2010). Marine mammals that live closer to the source of pollutants and those that feed on higher-level organisms have increased potential to accumulate toxins (Moon et al., 2010). The buildup of human-made persistent compounds in marine mammals not only increases their likelihood of contracting diseases or developing tumors, but also compromises the function of their reproductive systems (Fair et al., 2010). Oil and other chemical spills are a specific type of ocean contamination that can have damaging effects on some marine mammal species (see Matkin et al., 2008).

Habitat deterioration and loss is a major factor for almost all coastal and inshore species of marine mammals, especially those that live in rivers or estuaries, and it may include such factors as depleting a habitat's prey base and the complete loss of habitat (Kemp, 1996; Smith et al., 2009; Ayres et al., 2012). In some locations, especially where urban or industrial activities or commercial shipping is intense, anthropogenic noise is also being increasingly considered as a potential habitat level stressor. Noise is of particular concern to marine mammals because many species use sound as a primary sense for navigating, finding prey, avoiding predators, and communicating with other individuals. Noise may cause marine mammals to leave a habitat, impair their ability to communicate, or cause stress (Hildebrand, 2009; Tyack et al., 2011; Rolland et al., 2012; Erbe et al., 2012). Noise can cause behavioral disturbances, mask other sounds (including their own vocalizations), may result in injury and in some cases, may result in behaviors that ultimately lead to death (National Research Council, 2003; National Research Council, 2005; Nowacek et al., 2007; Würsig and Richardson, 2009; Southall et al., 2009; Tyack, 2009a). Anthropogenic noise is generated from a variety of sources including commercial shipping, oil and gas activities, commercial and recreational fishing, recreational boating and whale watching, offshore power generation, research (including sound from air guns, sonar, and telemetry), and military training and testing activities. Vessel noise in particular is a large contributor to noise in the ocean. Commercial shipping's contribution to ambient noise in the ocean has increased by as much as 12 dB over the last few decades (McDonald et al., 2008; Hildebrand, 2009).

Marine mammals as a whole are subject to the various influences and factors described above. If additional specific threats to individual species within the Study Area are known, those threats are described in the species accounts in Section 4, *Affected Species Status and Distribution*.

Density Estimates

For purposes of impacts analysis, the number of marine mammals potentially affected may be considered in terms of density, which is the number of animals present in the area affected by a given surface detonation. A significant amount of effort is required to collect and analyze survey data sufficient for producing useable marine species density estimates for large areas such as the HRC and is typically beyond the scope of any single organization. As a result, there is often no single source of density available for every area, species, and season of interest; density data are often compiled from multiple sources. The density estimates used for acoustic analysis in this document are from the U.S. Navy's Marine Species Density Database for the Pacific region, which includes the HRC (U.S. Department of the Navy, 2014). The Navy database includes a compilation of the best available density data from several primary sources and published works including survey data from NMFS within the U.S. Exclusive Economic Zone (EEZ) off the coast of Hawaii (hereafter referred to as the Hawaiian Islands EEZ). NMFS publishes annual stock assessment reports for various regions of U.S. waters, which cover all stocks of marine mammals within those waters (for abundance and distribution information on species potentially occurring within the Study Area, see Allen and Angliss [2014] and Carretta et al. [2015]). Other researchers often publish density data or research covering a particular marine mammal species or geographic area, which is integrated into the stock assessment reports.

For most marine mammal species, abundance is estimated using line-transect methods that derive densities based on sighting data collected during systematic ship or aerial surveys. Habitat-based models may also be used to model density as a function of environmental variables. Each source of data may use different methods to estimate density, and uncertainty in the estimate can be directly related to the method applied. Uncertainty in published density estimation is typically large because of the low number of sightings collected during surveys. Uncertainty characterization is an important consideration in marine mammal density estimation and some methods inherently result in greater uncertainty than others. Therefore, in selecting the best density value for a species, area, and time, it is important to select the data source that used a method providing the least uncertainty and the best estimate for the geographic area. A discussion of methods that provide the best estimate with the least uncertainty under different scenarios is provided in the Navy's density database technical report (U.S. Department of the Navy, 2014). For this IHA request, the Navy provided their most recent information on the type of model used to estimate density, along with the sources of uncertainty (expressed as a coefficient of variation), for each marine mammal species in the Hawaii region as part of their latest updates to the Navy Marine Species Density Database (NMSDD). At the time of writing this IHA Request, the latest technical report for the updated NMSDD was still under development, so the source documents for the coefficient of variation values may be more recent than the currently available NMSDD technical report referenced above. The most recent information is reproduced in Table 3-3.

Table 3-3. Marine Mammal Density Models and Uncertainty Values for the Hawaii Region

Species	Coefficient of Variation	Source	Model Type
Humpback whale	Main: 0.15 Outer strata and transit boxes: 0.30	Main Hawaii Islands inner stratum: Mobley et al. (2001) Outer strata and transit boxes: Calambokidis et al. (2008)	Main Hawaii Islands: line-transect Outer EEZ: mark-recapture
Blue whale	1.09	Bradford et al. (in review)	Multiple-covariate line-transect
Fin whale	1.05	Bradford et al. (in review)	Multiple-covariate line-transect
Sei whale	0.90	Bradford et al. (in review)	Multiple-covariate line-transect
Bryde's whale	Spatially-explicit	Forney et al. (2015)	Habitat-based density model
Minke whale	n/a	n/a	Acoustically derived from hydrophones using correction factors (Martin et al., 2015)
Sperm whale	Spatially-explicit	Forney et al. (2015)	Habitat-based density model
Pygmy sperm whale	1.12	Barlow (2006)	Multiple-covariate line-transect
Dwarf sperm whale	0.74	Barlow (2006)	Multiple-covariate line-transect
Killer whale	0.96	Bradford et al. (in review)	Multiple-covariate line-transect
False killer whale (Main Hawaiian Islands insular stock)	0.20	Oleson et al. (2010)	Population Viability Analysis

Species	Coefficient of Variation	Source	Model Type
False killer whale (all other stocks)	Spatially-explicit	Forney et al. (2015)	Habitat-based density model
Pygmy killer whale	0.53	Bradford et al. (in review)	Multiple-covariate line-transect
Short-finned pilot whale	Spatially-explicit	Forney et al. (2015)	Habitat-based density model
Melon-headed whale	0.20	Achettino (2010)	Mark-recapture
Bottlenose dolphin	Spatially-explicit	Forney et al. (2015)	Habitat-based density model
Pantropical spotted dolphin	Spatially-explicit	Forney et al. (2015)	Habitat-based density model
Striped dolphin	Spatially-explicit	Forney et al. (2015)	Habitat-based density model
Spinner dolphin	Spatially-explicit	Forney et al. (2015)	Habitat-based density model
Rough-toothed dolphin	Spatially-explicit	Forney et al. (2015)	Habitat-based density model
Fraser's dolphin	0.66	Bradford et al. (in review)	Multiple-covariate line-transect
Risso's dolphin	0.43	Bradford et al. (in review)	Multiple-covariate line-transect
Cuvier's beaked whale	0.69	Bradford et al. (in review)	Multiple-covariate line-transect
Blainville's beaked whale	1.13	Bradford et al. (in review)	Multiple-covariate line-transect
Longman's beaked whale	0.66	Bradford et al. (in review)	Multiple-covariate line-transect
Hawaiian monk seal	n/a	n/a	Navy derived

n/a = not available; EEZ = Exclusive Economic Zone

The NMSDD is considered the most relevant information source available for the Hawaii area and has been used in impacts analysis of previous military actions conducted near the Study Area. For some species, density estimates are uniform throughout the Hawaii region. For others, densities are provided in multiple smaller blocks. In these cases, the Air Force used density estimates corresponding to the block containing the Long Range Strike WSEP impact location. The resulting marine mammal seasonal density estimates used in this document are shown in Table 3-4. Long Range Strike WSEP missions are generally planned to occur in summer, and summer densities (June to August) are therefore considered most applicable. Assuming a summer time frame results in a density estimate of zero for most baleen whales, which are expected to be at higher latitude feeding grounds at that time.

Table 3-4. Marine Mammal Density Estimates

Species	Density Estimate (animals per square kilometer)			
	Fall	Spring	Summer	Winter
Humpback whale	0.02110	0.02110	0	0.02110
Blue whale	0.00005	0.00005	0	0.00005
Fin whale	0.00006	0.00006	0	0.00006
Sei whale	0.00016	0.00016	0	0.00016
Bryde's whale	0.00010	0.00010	0.00010	0.00010
Minke whale	0.00423	0.00423	0	0.00423
Sperm whale	0.00156	0.00156	0.00156	0.00156
Pygmy sperm whale	0.00291	0.00291	0.00291	0.00291
Dwarf sperm whale	0.00714	0.00714	0.00714	0.00714
Killer whale	0.00006	0.00006	0.00006	0.00006

Species	Density Estimate (animals per square kilometer)			
	Fall	Spring	Summer	Winter
False killer whale Main Hawaiian Islands insular stock)	0.00080	0.00080	0.00080	0.00080
False killer whale (all other stocks)	0.00071	0.00071	0.00071	0.00071
Pygmy killer whale	0.00440	0.00440	0.00440	0.00440
Short-finned pilot whale	0.00919	0.00919	0.00919	0.00919
Melon-headed whale	0.00200	0.00200	0.00200	0.00200
Bottlenose dolphin	0.00316	0.00316	0.00316	0.00316
Pantropical spotted dolphin	0.00622	0.00622	0.00622	0.00622
Striped dolphin	0.00335	0.00335	0.00335	0.00335
Spinner dolphin	0.00204	0.00204	0.00204	0.00204
Rough-toothed dolphin	0.00470	0.00470	0.00470	0.00470
Fraser's dolphin	0.00457	0.00457	0.00457	0.00457
Risso's dolphin	0.00470	0.00470	0.00470	0.00470
Cuvier's beaked whale	0.00030	0.00030	0.00030	0.00030
Blainville's beaked whale	0.00086	0.00086	0.00086	0.00086
Longman's beaked whale	0.00310	0.00310	0.00310	0.00310
Hawaiian monk seal	0.00003	0.00003	0.00003	0.00003

4.0 AFFECTED SPECIES STATUS AND DISTRIBUTION

This section provides information on the marine mammal species with potential occurrence in the Study Area. Information is provided for individual species, and for stocks when applicable. The MMPA defines a marine mammal "stock" as "a group of marine mammals of the same species or smaller taxon in a common spatial arrangement that interbreed when mature." For MMPA management purposes, a stock is considered an isolated population or group of individuals within a whole species that is found in the same area. However, due to lack of sufficient information, NMFS' recognized management stocks may include groups of multiple species, such as with two *Kogia* species. Marine mammal species may also be managed according to distinct population segments (DPS). A DPS is a population or group of populations that is discrete from other populations of the species and which is significant in relation to the species as a whole.

Up to 25 marine mammal species may occur in the Study Area, including 6 mysticetes (baleen whales), 18 odontocetes (dolphins and toothed whales), and 1 pinniped. Multiple stocks are designated in the Hawaii region for some of these species, resulting in a total of 40 stocks managed by NMFS or the U.S. Fish and Wildlife Service (USFWS) in the Hawaiian Islands EEZ. Many of the stock boundaries are based on water depth or distance from shore. Therefore, due to the Long Range Strike WSEP impact site location, not all stocks coincide with the mission area. Certain stocks of melon-headed whale, bottlenose dolphin, pantropical spotted dolphin, and spinner dolphin are excluded based on these criteria. Previously, all three stocks of false killer whales in the Hawaii region were considered to overlap within 40 and 93 km (about 22 to 50 NM) around Kauai. Revised stock boundaries define the Main Hawaiian Insular stock as occurring at a maximum distance of 72 km (39 NM) offshore, which does not overlap with the long range strike weapon impact location or surrounding potential marine mammal effects range (Figure 4-1). Therefore, this stock is not included in subsequent analyses. However, the Northwestern Hawaiian Islands and Hawaii Pelagic stocks are included.

Species for which some stocks in the Hawaii region are excluded from consideration, and the rationale for inclusion or exclusion, is provided in Table 4-1. All species and stocks occurring in the Hawaii region are shown in Table 4-2. Information on status, distribution, abundance, and ecology of each species is presented in the following subsections. The North Pacific right whale (*Eubalaena japonica*) is not included in the table or in impacts analyses provided later in this document. This species is considered "vagrant" in the area, as the Hawaii region is currently outside the typical geographic range (Reilly et al., 2008). The most recent known sightings in the Hawaii region occurred in 1996 and 1979 (Salden and Mickelsen, 1999; Herman et al., 1980; Rowntree et al., 1980).

In some instances in this section, references are made to various regions of the Pacific Ocean delineated by the National Oceanic and Atmospheric Administration (NOAA)/NMFS Science Centers. The Eastern North Pacific is the area in the Pacific Ocean that is east of 140 degrees (°) west (W) longitude and north of the equator. Similarly the Central North Pacific is the area north of the equator and between the International Date Line (180° W longitude) and 140° W longitude. The Eastern Tropical Pacific is the area roughly extending from the U.S.-Mexico Border west to Hawaii and south to Peru.

Figure 4-1. False Killer Whale Stock Boundaries

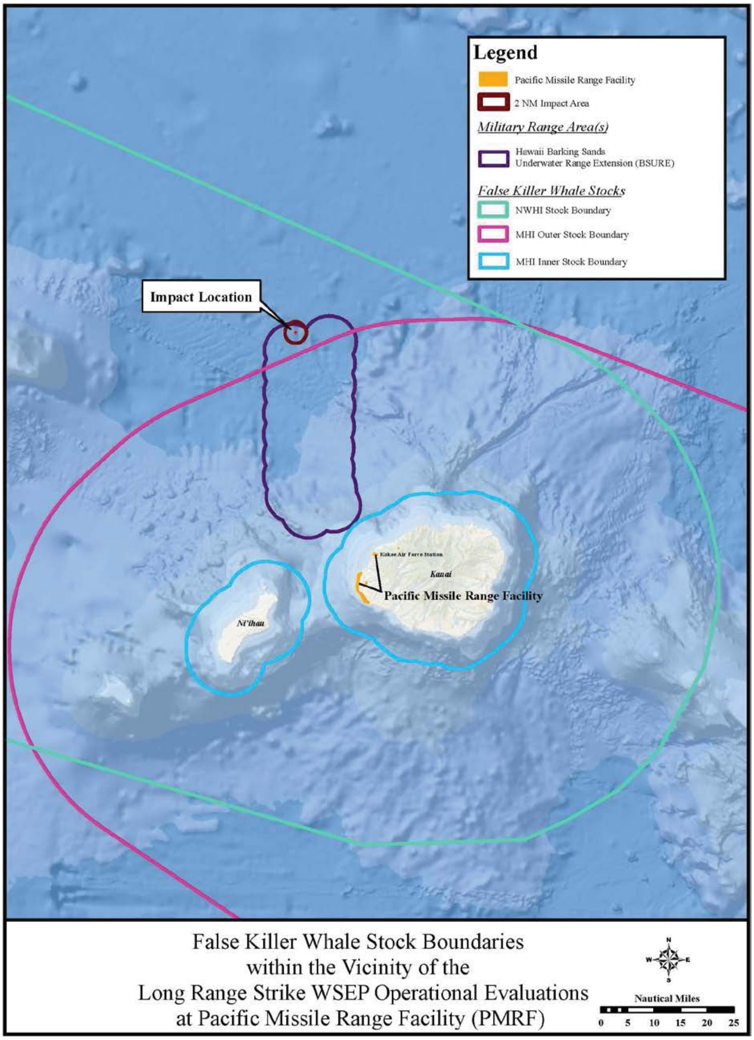


Table 4-1. Occurrence of Marine Mammal Species with Multiple Designated Stocks

Species	Stock[1]	Stock Boundary Designation	Occurrence in Mission Area (44 NM/81 km offshore; water depth 4,645 m)	
			Present	Not Present
False killer whale (*Pseudorca crassidens*)	Main Hawaiian Islands Insular	Animals inhabiting waters within 72 km (39 NM) of the Main Hawaiian Islands		X
	Northwestern Hawaiian Islands	Animals inhabiting waters within a 93 km (50 NM) radius of the Northwestern Hawaiian Islands, or the boundary of the Papahānaumokuākea Marine National Monument, with the radial boundary extended to the southeast to encompass Kauai and Niihau	X	
	Hawaii Pelagic	Animals inhabiting waters greater than 11 km (6 NM) from the Main Hawaiian Islands (there is no inner boundary within the Northwestern Hawaiian Islands)	X	
Melon-headed whale (*Peponocephala electra*)	Hawaiian Islands	Animals inhabiting waters throughout the Hawaiian Islands EEZ	X	
	Kohala Resident	Animals off the Kohala Peninsula and west coast of Hawaii Island and in less than 2,500-m water depth		X
Bottlenose dolphin (*Tursiops truncatus*)	Hawaii Pelagic	Animals inhabiting waters throughout the Hawaiian Islands EEZ	X	
	Kauai and Niihau Oahu 4-Island Hawaii Island	Animals occurring from the shoreline of the respective islands to 1,000-m water depth		X
Pantropical spotted dolphin (*Stenella attenuata*)	Hawaii Pelagic	Animals inhabiting waters throughout the Hawaiian Islands EEZ, outside of the insular stock areas	X	
	Oahu	Animals occurring from the shoreline of the respective islands to 20 km offshore		X
	4-Island			
	Hawaii Island	Animals occurring from the shoreline to 65 kilometers offshore of Hawaii Island		X
Spinner dolphin (*Stenella longirostris*)	Hawaii Pelagic	Animals inhabiting waters throughout the Hawaiian Islands EEZ, outside of island-associated stock boundaries	X	
	Hawaii Island	Animals occurring within 10 NM (19 km) of shore of the respective islands		X
	Oahu and 4-Island			
	Kauai and Niihau			
	Midway Atoll/Kure			
	Pearl and Hermes Reef			

EEZ = Exclusive Economic Zone; km = kilometer; m = meter; NM = nautical mile
[1]Stock designations and boundaries were obtained from Carretta et al., 2015

Table 4-2. Status of Marine Mammals in the Study Area

Common Name	Scientific Name	Stock	Stock Abundance (CV)[4]	Study Area Abundance (CV)[4]	Occurrence	ESA/MMPA Status
Mysticetes (baleen whales)						
Humpback whale[1]	*Megaptera novaeangliae*	Central North Pacific	10,103 (N/A)	4,491 (N/A)	Seasonal; throughout known breeding grounds during winter and spring (most common November through April)	Endangered/Depleted
Blue whale[2]	*Balaenoptera musculus*	Central North Pacific	81 (summer/fall) (1.14)	81 (summer/fall) (1.14)	Seasonal; infrequent winter migrant; few sightings, mainly fall and winter; considered rare	Endangered/Depleted
Fin whale[2]	*Balaenoptera physalus*	Hawaii	58 (summer/fall) (1.12)	58 (summer/fall) (1.12)	Seasonal, mainly fall and winter; considered rare	Endangered/Depleted
Sei whale[2]	*Balaenoptera borealis*	Hawaii	178 (summer/fall) (0.90)	178 (summer/fall) (0.90)	Rare; limited sightings of seasonal migrants that feed at higher latitudes	Endangered/Depleted
Bryde's whale[2]	*Balaenoptera brydei/edeni*	Hawaii	798 (0.28)	798 (0.28)	Uncommon; distributed throughout the Hawaiian EEZ	N/A
Minke whale[2]	*Balaenoptera acutorostrata*	Hawaii	No data	No data	Regular but seasonal (October-April)	N/A
Odontocetes (toothed whales and dolphins)						
Sperm whale[2]	*Physeter macrocephalus*	Hawaii	3,354 (0.34)	3,354 (0.34)	Widely distributed year-round; more likely in waters > 1,000 m depth, most often > 2,000 m	Endangered/Depleted
Pygmy sperm whale[2]	*Kogia breviceps*	Hawaii	No data	No data	Stranding numbers suggest this species is more common than previous survey sightings indicated	N/A
Dwarf sperm whale[2]	*Kogia sima*	Hawaii	No data	No data	Stranding numbers suggest this species is more common than previous survey sightings indicated	N/A

Common Name	Scientific Name	Stock	Stock Abundance (CV)[4]	Study Area Abundance (CV)[4]	Occurrence	ESA/MMPA Status
Killer whale[2]	*Orcinus orca*	Hawaii	101 (1.00)	101 (1.00)	Uncommon; infrequent sightings	N/A
False killer whale Hawaiian Islands Stock Complex[3]	*Pseudorca crassidens*	Main Hawaiian Islands Insular	151 (0.20)	Not applicable to study area	Regular	Endangered/Depleted
		Hawaii Pelagic	1,540 (0.67)	1,540 (0.67)	Regular	N/A
		Northwestern Hawaiian Islands	617 (1.11)	617 (1.11)	Regular	N/A
Pygmy killer whale[2]	*Feresa attenuata*	Hawaii	3,433 (0.52)	3,433 (0.52)	Year-round resident	N/A
Short-finned pilot whale[2]	*Globicephala macrorhynchus*	Hawaii	12,422 (0.43)	12,422 (0.43)	Commonly observed around Main Hawaiian Islands and Northwestern Hawaiian Islands	N/A
Melon-headed whale Hawaiian Islands Stock Complex[2]	*Peponocephala electra*	Hawaii Islands stock	5,794 (0.20)	5,794 (0.20)	Regular	N/A
		Kohala Resident Stock	447 (0.12)	Not applicable to study area	Regular	N/A
Bottlenose dolphin Hawaiian Islands Stock Complex[2]	*Tursiops truncatus*	Hawaii Pelagic	5,950 (0.59)	5,950 (0.59)	Common in deep offshore waters	N/A
		Kauai and Niihau	147 (0.11)	Not applicable to study area	Common in shallow nearshore waters ≤ 1,000 m depth)	N/A
		Oahu	594 (0.54)	Not applicable to study area	Common in shallow nearshore waters ≤ 1,000 m depth)	N/A
		4-Island Region	153 (0.24)	Not applicable to study area	Common in shallow nearshore waters ≤ 1,000 m depth)	N/A
		Hawaii Island	102 (0.13)	Not applicable to study area	Common in shallow nearshore waters ≤ 1,000 m depth)	N/A

Common Name	Scientific Name	Stock	Stock Abundance (CV)[4]	Study Area Abundance (CV)[4]	Occurrence	ESA/MMPA Status
Pantropical spotted dolphin Hawaiian Islands Stock Complex[2]	*Stenella attenuata*	Hawaii Pelagic	15,917 (0.40)	15,917 (0.40)	Common; primary occurrence between 100 and 4,000 m depth	N/A
		Oahu	No data	Not applicable to study area	Common; primary occurrence between 100 and 4,000 m depth	N/A
		4-Island Region	No data	Not applicable to study area	Common; primary occurrence between 100 and 4,000 m depth	N/A
		Hawaii Island	No data	Not applicable to study area	Common; primary occurrence between 100 and 4,000 m depth	N/A
Striped dolphin[2]	*Stenella coeruleoalba*	Hawaii	20,650 (0.36)	20,650 (0.36)	Occurs regularly year-round but infrequent sighting during survey (Barlow, 2006)	N/A
Spinner dolphin Hawaiian Islands Stock Complex[2]	*Stenella longirostris*	Hawaii Pelagic	No data	No data	Common year-round in offshore waters	N/A
		Hawaii Island	631 (0.09)	Not applicable to study area	Common year-round; rest in nearshore waters during the day and move offshore to feed at night	N/A
		Oahu and 4-Island	355 (0.09)	Not applicable to study area	Common year-round; rest in nearshore waters during the day and move offshore to feed at night	N/A
		Kauai and Niihau	601 (0.20)	Not applicable to study area	Common year-round; rest in nearshore waters during the day and move offshore to feed at night	N/A

Common Name	Scientific Name	Stock	Stock Abundance (CV)[4]	Study Area Abundance (CV)[4]	Occurrence	ESA/MMPA Status
		Midway Atoll/Kure	No data	Not applicable to study area	Common year-round; rest in nearshore waters during the day and move offshore to feed at night	N/A
		Pearl and Hermes Reef	No data	Not applicable to study area	Common year-round; rest in nearshore waters during the day and move offshore to feed at night	N/A
Rough-toothed dolphin[2]	*Steno bredanensis*	Hawaii Stock (Hawaiian Islands EEZ)	6,288 (0.39)	6,288 (0.39)	Common throughout the Main Hawaiian Islands and Hawaiian Islands EEZ	N/A
		Kauai/Niihau area (not a designated stock)	1,665 (0.33)	1,665 (0.33)	Common throughout the Main Hawaiian Islands and Hawaiian Islands EEZ	N/A
		Hawaii Island (not a designated stock)	198 (0.12)	Not applicable to study area	Common throughout the Main Hawaiian Islands and Hawaiian Islands EEZ	N/A
Fraser's dolphin[2]	*Lagenodelphis hosei*	Hawaii	16,992 (0.66)	16,992 (0.66)	Tropical species only recently documented within Hawaiian Islands EEZ (2002 survey)	N/A
Risso's dolphin[2]	*Grampus griseus*	Hawaii	7,256 (0.41)	7,256 (0.41)	Previously considered rare but multiple sightings in Hawaiian Islands EEZ during various surveys conducted from 2002-2012	N/A
Cuvier's beaked whale[2]	*Ziphius cavirostris*	Hawaii	1,941 (0.70)	1,941 (0.70)	Year-round occurrence but difficult to detect due to diving behavior	N/A
Blainville's beaked whale[2]	*Mesoplodon densirostris*	Hawaii	2,338 (1.13)	2,338 (1.13)	Year-round occurrence but difficult to detect due to diving behavior	N/A

Common Name	Scientific Name	Stock	Stock Abundance (CV)[4]	Study Area Abundance (CV)[4]	Occurrence	ESA/MMPA Status
Longman's beaked whale[2]	*Indopacetus pacificus*	Hawaii	4,571 (0.65)	4,571 (0.65)	Considered rare; however, multiple sightings during 2010 survey	N/A
Pinnipeds						
Hawaiian monk seal[2]	*Neomonachus schauinslandi*	Hawaii	1,153 (Northwestern Hawaiian Islands)	138 (Main Hawaiian Islands)	Predominantly occur at Northwestern Hawaiian Islands; approximately 138 in Main Hawaiian Islands	Endangered/Depleted

≤ = less than or equal to; CV = coefficient of variation; EEZ = Exclusive Economic Zone; ESA = Endangered Species Act; m = meters; MMPA = Marine Mammal Protection Act; N/A = not applicable

[1]Stock designations and abundance were obtained from Allen and Angliss, 2014

[2]Stock designations and abundance were obtained from Carretta et al., 2015

[3]Stock designations were obtained from Carretta et al., 2015 and Bradford et al., 2015; abundance was obtained from Bradford et al., 2015

[4]The stated coefficient of variation (CV) is an indicator of uncertainty in the abundance estimate and describes the amount of variation with respect to the statistical population mean. It is expressed as a fraction or percentage and can range upward from zero (no uncertainty) to high values (greater uncertainty). For example, a CV of 0.8 would indicate much higher uncertainty than a CV of 0.2. When the CV reaches or exceeds 1.0, the estimate is highly uncertain, as the variation could be 100 percent or more of the estimated abundance. The uncertainty associated with movements of animals into or out of an area (due to factors such as prey availability or oceanographic conditions) is much larger than is indicated by the statistical CVs that are given.

4.1 Humpback Whale (*Megaptera novaeangliae*)

Status and Management

Humpback whales are currently listed as depleted under the MMPA and endangered under the ESA. In the U.S. North Pacific Ocean, the stock structure of humpback whales is defined based on feeding areas because of the species' fidelity to feeding grounds (Carretta et al., 2015). Three stocks are currently designated by NMFS in the North Pacific: (1) the Central North Pacific stock, consisting of winter and spring populations of the Hawaiian Islands that migrate to northern British Columbia and Alaska, the Gulf of Alaska, the Bering Sea, and Aleutian Islands; (2) the Western North Pacific stock, consisting of winter and spring populations off Asia that migrate to Russia and the Bering Sea and Aleutian Islands; and (3) the California/Oregon/Washington stock, consisting of animals along the U.S. west coast.

However, in April 2015, NMFS announced a proposal to divide the species into 14 DPSs worldwide, including a Hawaii DPS, and to revise the listing status for the various populations (50 Code of Federal Regulations (CFR) Parts 223 and 224, 21 April 2015). Under the proposal, two DPSs would be designated as endangered under the ESA, two would be designated as threatened, and the remainder would not have an ESA listing status. The proposed Hawaii DPS, which is the same as the current Central North Pacific stock, is not included in the four DPSs that would be listed under the ESA. NMFS does not consider the proposed Hawaii DPS to be in danger of extinction, or likely to become so in the foreseeable future. Therefore, the DPS would not be listed as endangered or threatened under the proposed revision. At the time this document was prepared, NMFS was soliciting public comment on the proposed rule.

The Hawaiian Islands Humpback Whale National Marine Sanctuary, which was designated in 1992 to protect humpback whales and their habitat, is located within the HRC. The sanctuary is delineated from the shoreline to the 100-fathom (183 m) isobath in discrete areas of the Hawaiian Islands region, including an area off the north shore of Kauai. However, the sanctuary does not coincide with the Long Range Strike WSEP mission location, which is located in water depth of over 4,600 meters.

Geographic Range and Distribution

General. Humpback whales are distributed worldwide in all major oceans and most seas. They typically are found during the summer in high-latitude feeding grounds and during the winter in the tropics and subtropics around islands, over shallow banks, and along continental coasts, where calving occurs.

Insular Pacific-Hawaiian Large Marine Ecosystem. The Central North Pacific stock of humpback whales occurs throughout known breeding grounds in the Hawaiian Islands during winter and spring (November through April) (Allen and Angliss, 2013). Peak occurrence is from late February through early April (Carretta et al., 2010; Mobley et al., 2000), with a peak in acoustic detections in March (Norris et al., 1999). A recent study that also used acoustic recordings near the Northwestern Hawaiian Islands indicates that humpback whales were present from early December through early June (Lammers et al., 2011). During the fall-winter period, primary occurrence is expected from the coast to 50 NM offshore (Mobley et al., 2000; Mobley, 2004). The greatest densities of humpback whales (including calves) are in the four-island region consisting of Maui, Molokai, Kahoolawe, and Lanai, as well as Penguin Bank (Mobley et al., 2000; Maldini et al., 2005) and around Kauai (Mobley, 2005). During the spring-summer period, secondary occurrence is expected offshore out to 50 NM. Occurrence farther offshore or inshore (e.g., Pearl Harbor) has rarely been documented.

Survey results suggest that humpbacks may also be wintering in the northwestern Hawaiian Island region and not just using it as a migratory corridor. A recent study that also used acoustic recordings near the Northwestern Hawaiian Islands indicates that humpback whales were present from early December through early June (Lammers et al., 2011). It is not yet known if this represents a previously undocumented breeding stock or if the whales occurring at the Northwestern Hawaiian Islands are part of the same population that winters near the Main Hawaiian Islands.

In breeding grounds, females with calves occur in significantly shallower waters than other groups of whales, and breeding adults use deeper more offshore waters (Smultea, 1994; Ersts and Rosenbaum, 2003). The habitat requirements of wintering humpbacks appear to be controlled by the conditions necessary for calving, such as warm water (75 to 80 degrees [°] Fahrenheit [24° to 28° Celsius]) and relatively shallow, low-relief ocean bottom in protected areas, created by islands or reefs (Smultea, 1994; Clapham, 2000; Craig and Herman, 2000).

Open Ocean. Most humpback whale sightings are in nearshore and continental shelf waters; however, humpback whales frequently travel through deep oceanic waters during migration (Calambokidis et al., 2001; Clapham and Mattila, 1990; Clapham, 2000). Humpback migrations are complex and cover long distances (Calambokidis, 2009; Barlow et al., 2011). Each year, most humpback whales migrate from high-latitude summer feeding grounds to low latitude winter breeding grounds, one of the longest migrations known for any mammal; individuals can travel nearly 4,970 miles (7,998.4 km) from feeding to breeding areas (Clapham and Mead, 1999). Humpback whales that breed in Hawaii generally migrate to northern British Columbia and southeast Alaska to feed. Animals breeding in Hawaii have also been "matched" (identified as the same individual) to humpbacks feeding in southern British Columbia and northern Washington (where matches were also found to animals breeding in Central America). Hawaii humpbacks are also known to feed in the Gulf of Alaska, the Aleutian Islands, and Bering Sea, where surprisingly matches were also found to animals that breed near islands off Mexico (Forestell and Urban-Ramirez, 2007; Barlow et al., 2011; Lagerquist et al., 2008) and between Japan and Hawaii (Salden et al., 1999). This study indicates that humpback whales migrating between Hawaii and British Columbia/southeast Alaska must cross paths with humpback whales migrating between the Gulf of Alaska/Aleutian Islands/Bering Sea and islands off Mexico. In addition, based on the identification of individual whales, there is evidence that some humpback whales (most likely males) move between winter breeding areas in Hawaii and Mexico (Forestall and Urban-Ramirez, 2007) and Hawaii and Japan (Salden et al., 1999).

Satellite tagging of humpback whales in the Hawaiian Islands found that one adult traveled 155 miles (249.4 km) to Oahu, Hawaii in 4 days, while a different individual traveled to Penguin Bank and five islands, totaling 530 miles (852.9 km) in 10 days. Both of these trips imply faster travel between the islands than had been previously recorded (Mate et al., 1998). Three whales traveled independent courses, following north and northeast headings toward the Gulf of Alaska, with the fastest averaging 93 miles (150 km) per day. At this rate, the animal would take an estimated 39 days to travel the entire 2,600 miles (4,200 km) migration route to the upper Gulf of Alaska (Mate et al., 1998).

Population and Abundance

The overall abundance of humpback whales in the north Pacific was recently estimated at 21,808 individuals (coefficient of variation [CV] = 0.04; this is an indicator of uncertainty and is described in the footnote in Table 4-2), confirming that this population of humpback whales has continued to increase and is now greater than some pre-whaling abundance estimates (Barlow et al., 2011). Data indicate the north Pacific population has been increasing at a rate of between 5.5 percent and 6.0 percent per year, approximately doubling every 10 years (Calambokidis et al., 2008). The Central North Pacific stock has been estimated at 10,103 individuals on wintering grounds throughout the Main Hawaiian Islands (Allen and Angliss, 2013). The Hawaiian Islands Humpback Whale National Marine Sanctuary reported in 2010 that over 50 percent of the entire North Pacific humpback whale population migrates to Hawaiian waters each year (NOAA, 2010). Based on aerial surveys conducted around the Main Hawaiian Islands, the number of humpback whales was estimated at 4,491 (Mobley et al., 2001b).

Predator/Prey Interactions

The most common invertebrate prey are krill (tiny crustaceans); the most common fish prey are herring, mackerel, sand lance, sardines, anchovies, and capelin (Clapham and Mead, 1999). Feeding occurs both at the surface and in deeper waters, wherever prey is abundant. Humpback whales are the only species of baleen whale that show strong evidence of cooperation when they feed in large groups (D'Vincent et al., 1985). It is believed that minimal feeding occurs in wintering grounds, such as the Hawaiian Islands (Balcomb, 1987; Salden, 1989). This species is known to be attacked by both killer whales and false killer whales as evidenced by tooth rake scars on their bodies and fins (Jefferson et al., 2015).

Species Specific Threats

Entanglement in fishing gear poses a threat to individual humpback whales throughout the Pacific. Humpback whales from the Central North Pacific stock have been reported seriously injured and killed from entanglement in fishing gear while in their Alaskan feeding grounds (Allen and Angliss, 2013). From 2003 to 2007, an average of 3.4 humpback whales per year were seriously injured or killed due to entanglements with commercial fishing gear in Alaskan waters. This number is considered a minimum since observers have not been assigned to several fisheries known to interact with this stock and quantitative data on Canadian fishery entanglements are uncertain (Allen and Angliss, 2013). In the Hawaiian Islands, there are also reports of humpback whale entanglements with fishing gear. Between 2002 and 2014, the Hawaiian Islands Disentanglement Network responded to 139 confirmed large whale entanglement reports (Hawaiian Islands Humpback Whale National Marine Sanctuary, 2014). All but three of the reports (a sei whale and two sperm whales) involved humpback whales. In the 2013-2014 season, at least 13 whales were reported as entangled, with fishing gear (crab trap and longline gear) confirmed in three of the events.

Humpback whales, especially calves and juveniles, are highly vulnerable to ship strikes. Younger whales spend more time at the surface, are less visible, and are found closer to shore (Herman et al., 1980; Mobley et al., 1999), thereby making them more susceptible to collisions. In their Alaskan feeding grounds, eight ship strikes were implicated in mortality or serious injuries of humpback whales between 2003 and 2007 and seven between 2006 and 2010 (Allen and Angliss, 2011; Allen and Angliss, 2013); when they migrate to and from Alaska, some of these whales spend time in Hawaii.

In the Hawaiian Islands, there were nine reported ship collisions with humpback whales in 2006 (none involved Navy vessels), as recorded by the NMFS Pacific Islands Region Marine Mammal Response Network Activity Updates (NMFS, 2007a). The number of confirmed ship strike reports was greater in 2007/2008; there were 12 reported ship-strikes with humpback whales: 9 reported as hit by vessels, and 3 observed with wounds indicating a recent ship strike (NMFS, 2008a). A humpback carcass was discovered on the shore of west Molokai in 2010 with indications that the death resulted from trauma consistent with a ship strike (NMFS, 2010e).

Humpback whales are potentially affected by loss of habitat, loss of prey, underwater noise, and pollutants. The Central North Pacific stock of humpback whales is the focus of whale-watching activities in both its feeding grounds (Alaska) and breeding grounds (Hawaii). Regulations addressing minimum approach distances and vessel operating procedures are in place to help protect the whales; however, there is still concern that whales may abandon preferred habitats if the disturbance is too high (Allen and Angliss, 2010).

4.2 Blue Whale (*Balaenoptera musculus*)

The world's population of blue whales can be separated into three subspecies, based on geographic location and some morphological differences. The true blue whales have been divided into two subspecies found in the northern hemisphere (*Balaenoptera musculus musculus*) and the southern hemisphere (*Balaenoptera musculus intermedia*). The third subspecies, the pygmy blue whale (*Balaenoptera musculus brevicauda*), is known to have overlapping ranges with both subspecies of true blue whales (Best et al., 2003; Reeves et al., 2002).

Status and Management

The blue whale is listed as endangered under the ESA and as depleted under the MMPA. For the MMPA stock assessment reports, the Central North Pacific Stock of blue whales includes animals found around the Hawaiian Islands during winter (Carretta et al., 2015).

Geographic Range and Distribution

General. The blue whale inhabits all oceans and typically occurs near the coast, over the continental shelf, though it is also found in oceanic waters. Their range includes the California Current and Insular Pacific-Hawaiian Large Marine Ecosystems, and the open ocean. Blue whales have been sighted, acoustically recorded, and satellite tagged in the eastern tropical Pacific (Ferguson, 2005; Stafford et al., 2004).

Insular Pacific-Hawaiian Large Marine Ecosystem. Blue whales are found seasonally in the Hawaii region, but sighting frequency is low. Whales feeding along the Aleutian Islands of Alaska likely migrate to offshore waters north of Hawaii in winter.

Open Ocean. Most blue whale sightings are in nearshore and continental shelf waters; however, blue whales frequently travel through deep oceanic waters during migration (Širović et al., 2004). Most baleen whales spend their summers feeding in productive waters near the higher latitudes and winters in the warmer waters at lower latitudes (Širović et al., 2004). Blue whales belonging to the western Pacific stock may feed in summer, south of the Aleutians and in the Gulf of Alaska, and migrate to wintering grounds in lower latitudes in the western Pacific and central Pacific, including Hawaii (Stafford et al., 2004; Watkins et al., 2000).

Population and Abundance

In the north Pacific, up to five distinct populations of blue whales are believed to occur, although only one stock is currently identified. The overall abundance of blue whales in the eastern tropical Pacific is estimated at 1,400 individuals. The most recent survey data indicate a summer/fall abundance estimate of 81 individuals (CV = 1.14) in the Hawaiian Islands EEZ (Carretta et al., 2015). This estimate could potentially be low, as the majority of blue whales would be expected to be at higher latitude feeding grounds at that time.

Predator/Prey Interactions

This species preys almost exclusively on various types of zooplankton, especially krill. Blue whales lunge feed and consume approximately 6 tons (5,500 kilograms) of krill per day (Jefferson et al., 2015; Pitman et al., 2007). They sometimes feed at depths greater than 330 feet (100 m), where their prey maintains dense groupings (Acevedo-Gutiérrez et al., 2002). Blue whales have been documented to be preyed on by killer whales (Jefferson et al., 2015; Pitman et al., 2007). There is little evidence that killer whales attack this species in the north Atlantic or southern hemisphere, but 25 percent of photo-identified whales in the Gulf of California carry rake scars from killer whale attacks (Sears and Perrin, 2008).

Species Specific Threats

Blue whales are considered to be susceptible to entanglement in fishing gear and ship strikes.

4.3 Fin Whale (*Balaenoptera physalus*)

Status and Management

The fin whale is listed as endangered under the ESA and as depleted under the MMPA. Pacific fin whale population structure is not well known. In the North Pacific, recognized stocks include the California/Oregon/Washington, Hawaii, and Northeast Pacific stocks (Carretta et al., 2015).

Geographic Range and Distribution

General. The fin whale is found in all the world's oceans and is the second largest species of whale (Jefferson et al., 2015). Fin whales prefer temperate and polar waters and are scarcely seen in warm, tropical waters (Reeves et al., 2002). Fin whales typically congregate in areas of high productivity. They spend most of their time in coastal and shelf waters, but can often be found in waters of approximately 6,562 feet (2,000 m) (Aissi et al., 2008; Reeves et al., 2002). Attracted for feeding, fin whales are often seen closer to shore after periodic patterns of upwelling and the resultant increased krill density (Azzellino et al., 2008). This species of whale is not known to have a specific habitat and is highly adaptable, following prey, typically off the continental shelf (Azzellino et al., 2008; Panigada et al., 2008). The range of the fin whale is known to include the Insular Pacific-Hawaiian Large Marine Ecosystems and the open ocean.

Insular Pacific-Hawaiian Large Marine Ecosystem. Fin whales are found in Hawaiian waters, but this species is considered to be rare in this area (Carretta et al., 2010; Shallenberger, 1981). There are known sightings from Kauai and Oahu, and a single stranding record from Maui (Mobley et al., 1996; Shallenberger, 1981; U.S. Department of the Navy, 2011). Summer/fall shipboard surveys of the Hawaiian Islands EEZ resulted in five sightings in 2002 and two sightings in 2010 (Barlow, 2003; Bradford et al., 2013). A single sighting was made during aerial surveys from 1993 to 1998 (Mobley et al., 1996; Mobley et al., 2000). The most recent sighting was a single juvenile fin whale reported off Kauai in 2011 (U.S. Department of the Navy, 2011). Based on sighting data and acoustic recordings, fin whales are likely to occur in Hawaiian waters mainly in fall and winter (Barlow et al., 2006; Barlow et al., 2008; Barlow et al., 2004).

Open Ocean. Fin whales have been recorded in the eastern tropical Pacific (Ferguson, 2005) and are frequently sighted there during offshore ship surveys. Fin whales are relatively abundant in north Pacific offshore waters, including areas off Hawaii (Berzin and Vladimirov, 1981; Mizroch et al., 2009). Locations of breeding and calving grounds for the fin whale are unknown, but it is known that the whales typically migrate seasonally to higher latitudes every year to feed and migrate to lower latitudes to breed (Kjeld et al., 2006; MacLeod et al., 2006b). The fin whale's ability to adapt to areas of high productivity controls migratory patterns (Canese et al., 2006; Reeves et al., 2002). Fin whales are one of the fastest cetaceans, capable of attaining speeds of 25 miles (40.2 km) per hour (Jefferson et al., 2015; Marini et al., 1996).

Population and Abundance

Based on summer/fall surveys in the Hawaii EEZ, the current best available abundance estimate for the Hawaii stock of fin whales is 58 (CV = 1.12). This may be an underestimate because the majority of blue would be expected to be at higher latitude feeding grounds at the time the surveys were conducted (Carretta et al., 2015).

Predator/Prey Interactions

This species preys on small invertebrates such as copepods, squid, and schooling fishes such as capelin, herring, and mackerel (Goldbogen et al., 2006; Jefferson et al., 2015). The fin whale is not known to have a significant number of predators. However, in regions where killer whales are abundant, some fin whales exhibit attack scars on their flippers, flukes, and flanks, suggesting possible predation by killer whales (Aguilar, 2008).

Species Specific Threats

Fin whales are susceptible to ship strikes and entanglement in fishing gear.

4.4 Sei Whale (*Balaenoptera borealis*)

The sei whale is a medium-sized rorqual falling in size between fin whale and Bryde's whale and, given the difficulty of some field identifications and similarities in the general appearance of the three species, may sometimes be recorded in surveys as unidentified rorqual.

Status and Management

The sei whale is listed as endangered under the ESA and as depleted under the MMPA. A recovery plan for the sei whale was completed in 2011 and provides a research strategy for obtaining data required to estimate population abundance and trends, and to identify factors that may be limiting the recovery of this species (NMFS, 2011d). Although the International Whaling Commission recognizes one stock of sei whales in the North Pacific, some evidence indicates that more than one population exists. For the MMPA stock assessment reports, sei whales in the Pacific EEZ are divided into three areas: Hawaii, California/Oregon/Washington, and Alaska (Carretta et al., 2015).

Geographic Range and Distribution

General. Sei whales have a worldwide distribution and are found primarily in cold temperate to subpolar latitudes. During the winter, sei whales are found from 20° N to 23° N and during the summer from 35° N to 50° N (Horwood, 2009; Masaki, 1976; Masaki, 1977; Smultea et al., 2010). However, a recent survey of the Northern Mariana Islands recorded sei whales south of 20° North (N) in the winter (Fulling et al., 2011). They are considered absent or at very low densities in most equatorial areas.

Insular Pacific-Hawaiian Large Marine Ecosystem. The first verified sei whale sighting made nearshore of the Main Hawaiian Islands occurred in 2007 (Smultea et al., 2007; Smultea et al., 2010) and included the first subadults seen in the Main Hawaiian Islands. A line-transect survey conducted in February 2009 by the Cetacean Research Program surrounding the Hawaiian Islands resulted in the sighting of three Bryde's/sei whales. An additional sighting occurred in 2010 of Perret Seamount (U.S. Department of Navy, 2011). In March 2011 off Maui, the Hawaiian Islands Entanglement Response Network found a subadult sei whale entangled in rope and fishing gear (NMFS, 2011c). An attempt to disentangle the whale was unsuccessful although a telemetry buoy attached to the entangled gear was reported to be tracking the whale over 21 days as it moved north and over 250 NM from the Hawaiian Islands.

The sei whale has been considered rare in the Hawaii region based on reported sighting data and the species' preference for cool temperate waters. Sei whales were not sighted during aerial surveys conducted within 25 NM of the Main Hawaiian Islands from 1993 to 1998 (Mobley et al., 2000). Based on sightings made during the NMFS-Southwest Fisheries Science Center shipboard survey assessment of Hawaiian cetaceans (Barlow et al., 2004), sei whales were expected to occur in deep waters on the north side of the islands only. However, in 2007 two sei whale sightings occurred north of Oahu, Hawaii, during a short survey in November, and these included three subadult whales. These latter sightings suggest that the area north of the Main Hawaiian Islands may be part of a reproductive area for north Pacific sei whales (Smultea et al., 2010). Summer/fall shipboard surveys of the Hawaiian Islands EEZ resulted in four sightings in 2002 and three in 2010 (Barlow, 2003; Bradford et al., 2013).

Open Ocean. Sei whales are most often found in deep oceanic waters of the cool temperate zone. They appear to prefer regions of steep bathymetric relief, such as the continental shelf break, canyons, or basins between banks and ledges (Best and Lockyer, 2002; Gregr and Trites, 2001; Kenney and Winn, 1987; Schilling et al., 1992). On feeding grounds, the distribution is largely associated with oceanic frontal systems (Horwood, 1987). Characteristics of preferred breeding grounds are unknown, since they have generally not been identified.

Sei whales spend the summer feeding in high latitude subpolar latitudes and return to lower latitudes to calve in winter. Whaling data provide some evidence of differential migration patterns by reproductive class, with females arriving at and departing from feeding areas earlier than males (Horwood, 1987; Perry et al., 1999). Sei whales are known to swim at speeds greater than 15 miles (25 km) per hour and may be the second fastest cetacean, after the fin whale (Horwood, 2009; Jefferson et al., 2015).

Population and Abundance

Based on summer/fall surveys, the best current estimate of abundance for the Hawaii stock of sei whales is 178 animals (CV = 0.90). This abundance estimate is considered the best available estimate for the Hawaiian Islands EEZ, but may be an underestimate, as sei whales are expected to be mostly at higher latitudes on their feeding grounds during this time of year. No data are available on current population trends.

Predator/Prey Interactions

In the north Pacific, sei whales feed on a diversity of prey, including copepods, krill, fish (specifically sardines and anchovies), and cephalopods (squids, cuttlefish, octopuses) (Horwood, 2009; Nemoto and Kawamura, 1977). Feeding occurs primarily around dawn, which appears to be correlated with vertical migrations of prey species (Horwood, 2009). Unlike other rorquals, the sei whale skims to obtain its food, although, like other rorqual species, it does some lunging and gulping (Horwood, 2009).

Sei whales, like other large baleen whales, are likely subject to occasional attacks by killer whales.

Species Specific Threats

Based on the statistics for other large whales, it is likely that ship strikes also pose a threat to sei whales.

4.5 Bryde's Whale (*Balaenoptera brydei/edeni*)

Bryde's whales are among the least known of the large baleen whales. Their classification and true number remain uncertain (Alves et al., 2010). Until recently, all medium-sized baleen whales were considered members of one of two species, Bryde's whale or sei whale. However, at least three genetically distinct types of these whales are now known, including the so-called pygmy or dwarf Bryde's whales (*Balaenoptera brydei*) (Kato and Perrin, 2008; Rice, 1998). The International Whaling Commission continues to use the name *Balaenoptera edeni* for all Bryde's-like whales, although at least two species are recognized. In 2003, a new species (Omura's whale, *Balaenoptera omurai*) was described, and it became evident that the term pygmy Bryde's whale had been mistakenly used for specimens of *Balaenoptera omurai* (Reeves et al., 2004). Omura's whale is not currently known to occur in the Study Area and appears to be restricted to the western Pacific and Indian oceans (Jefferson et al., 2015); therefore, is not described or evaluated in this document.

Status and Management

This species is protected under the MMPA and is not listed under the ESA. The International Whaling Commission recognizes three management stocks of Bryde's whales in the north Pacific: Western North Pacific, Eastern North Pacific, and East China Sea (Donovan, 1991), though the biological basis for defining separate stocks of Bryde's whales in the central north Pacific is not clear (Carretta et al., 2010). For MMPA stock assessment reports, Bryde's whales within the Pacific U.S. EEZ are divided into two areas: Hawaii and Eastern Pacific (Carretta et al., 2015).

Geographic Range and Distribution

Insular Pacific-Hawaiian Large Marine Ecosystem. Bryde's whales are only occasionally sighted in the Insular Pacific-Hawaiian Large Marine Ecosystems (Carretta et al., 2010; Jefferson et al., 2015; Smultea et al., 2008b). The first verified Bryde's whale sighting made nearshore of the Main Hawaiian Islands occurred in 2007 (Smultea et al., 2008b; Smultea et al., 2010). A line-transect survey conducted in February 2009 by the Cetacean Research Program surrounding the Hawaiian Islands resulted in the sighting of three Bryde's/sei whales (Oleson and Hill, 2009). Summer/fall shipboard surveys of waters within the Hawaiian Islands EEZ in 2002 and 2010 resulted in 13 and 30 Bryde's whale sightings, respectively (Barlow, 2003; Bradford et al., 2013). Sightings are more frequent in the Northwestern Hawaiian Islands than in the Main Hawaiian Islands (Barlow et al., 2004; Carretta et al., 2010; Smultea et al., 2008b; Smultea et al., 2010).

Open Ocean. Bryde's whales occur primarily in offshore oceanic waters of the north Pacific. Data suggest that winter and summer grounds partially overlap in the central north Pacific (Kishiro, 1996; Ohizumi et al., 2002). Bryde's whales are distributed in the central north Pacific in summer; the southernmost summer distribution of Bryde's whales inhabiting the central north Pacific is about 20° N (Kishiro, 1996). Some whales remain in higher latitudes (around 25° N) in both winter and summer, but are not likely to move poleward of 40° N (Jefferson et al., 2015; Kishiro, 1996). Bryde's whales in some areas of the world are sometimes seen very close to shore and even inside enclosed bays (Baker and Madon, 2007; Best et al., 1984).

Long migrations are not typical of Bryde's whales, although limited shifts in distribution toward and away from the equator, in winter and summer, have been observed (Best, 1996; Cummings, 1985). They have been recorded swimming at speeds of 15 miles (24.1 km) per hour (Jefferson et al., 2015; Kato and Perrin, 2008).

Population and Abundance

Little is known of population status and trends for most Bryde's whale populations. Current genetic research confirms that gene flow among Bryde's whale populations is low and suggests that management actions treat each as a distinct entity to ensure proper conservation of biological diversity (Kanda et al., 2007). A 2010 shipboard line-transect survey of the entire Hawaiian Islands EEZ yielded an abundance estimate of 798 (CV = 0.28) Bryde's whales (Bradford et al., 2013), which is the best available abundance estimate for the Hawaiian stock.

Predator/Prey Interactions

Bryde's whales primarily feed on schooling fish and are lunge feeders. Prey includes anchovy, sardine, mackerel, herring, krill, and other invertebrates such as pelagic red crab (Baker and Madon, 2007; Jefferson et al., 2015; Nemoto and Kawamura, 1977). Bryde's whales have been observed using "bubble nets" to herd prey (Jefferson et al., 2015; Kato and Perrin, 2008). Bubble nets are used in a feeding strategy where the whales dive and release bubbles of air that float up in a column and trap prey inside where they lunge through the column to feed. Bryde's whale is known to be prey for killer whales, as evidenced by an aerial observation of 15 killer whales attacking a Bryde's whale in the Gulf of California (Weller, 2008).

Species Specific Threats

Serious injury or mortality from interactions with fishing gear poses a threat to Bryde's whales.

4.6 Minke Whale (*Balaenoptera acutorostrata*)

Until recently, all minke whales were classified as the same species. However, the taxonomy is currently complex, as NMFS recognizes two species: northern or common minke whale (*Balaenoptera* *acutorostrata*) and Antarctic minke whale (*Balaenoptera bonaerensis*) (NOAA, 2014). The dwarf minke whale form (*Balaenoptera acutorostrata* subspecies, no official scientific name) is a possible third species, and there are several other subspecies as well. The northern minke whale is divided into two subspecies, *Balaenoptera acutorostrata scammoni* in the north Pacific and *Balaenoptera acutorostrata acutorostrata* in the north Atlantic. Accordingly, only *Balaenoptera acutorostrata scammoni* occurs in the Study Area. For stock assessment reports, NMFS currently recognizes three stocks in the Pacific U.S. EEZ: Hawaii, California/Oregon/Washington, and Alaska (Carretta et al., 2015).

Status and Management

The minke whale is protected under the MMPA and is not listed under the ESA.

Geographic Range and Distribution

General. The minke whale range is known to include the California Current and Insular Pacific-Hawaiian Large Marine Ecosystems, North Pacific Gyre, and the North Pacific Transition Zone (Okamura et al., 2001; Yamada, 1997). The northern boundary of their range is within subarctic and arctic waters (Kuker et al., 2005).

Insular Pacific-Hawaiian Large Marine Ecosystem. Minke whales previously were considered a rare species in Hawaiian waters due to limited sightings during surveys. The first documented sighting of a minke whale close to the Main Hawaiian Islands was made off the southwest coast of Kauai in 2005 (Norris et al., 2005; Rankin et al., 2007). However, recent research suggests minke whales are somewhat common in Hawaii (Rankin et al., 2007; U.S. Department of the Navy, 2011). Whales found in the Hawaii region are known to belong to seasonally migrating populations that feed in higher latitudes (Barlow, 2006). During a survey around the Hawaiian Islands, minke whales were identified as the source of the mysterious “boing” sound of the north Pacific Ocean, specifically offshore of Kauai and closer in, near the PMRF, Barking Sands region (Barlow et al., 2004; Rankin and Barlow, 2005). This new information has allowed acoustical detection of minke whales, although they are rarely observed during visual surveys (Barlow, 2006; Barlow et al., 2004; Rankin et al., 2007). Recent research using a survey vessel’s towed acoustic array and the Navy’s hydrophones off Kauai in 2009-2010 (35 days total) provided bearings to 1,975 minke whale “boing” vocalizations located within the instrumented range offshore of the PMRF (U.S. Department of the Navy, 2011).

Open Ocean. These whales generally participate in annual migrations between low-latitude breeding grounds in the winter and high-latitude feeding grounds in the summer (Kuker et al., 2005). Minke whales generally occupy waters over the continental shelf, including inshore bays, and even occasionally enter estuaries. However, records from whaling catches and research surveys worldwide indicate an open ocean component to the minke whale’s habitat. The migration paths of the minke whale include travel between breeding to feeding grounds and have been shown to follow patterns of prey availability (Jefferson et al., 2015).

Population and Abundance

There currently is no population estimate for the Hawaii stock of minke whale, which appears to occur seasonally (about October to April) around the Hawaiian Islands. During summer/fall shipboard surveys of the Hawaiian Islands EEZ in 2002 and 2010 (Barlow, 2003; Bradford et al., 2013), one individual was sighted in each year. However, the majority of individuals would typically be expected to be located farther north at this time of year.

Predator/Prey Interactions

This species preys on small invertebrates and schooling fish, such as sand eel, pollock, herring, and cod. Similar to other rorquals, minke whales are lunge feeders, often plunging through patches of shoaling fish or krill (Hoelzel et al., 1989; Jefferson et al., 2015). In the north Pacific, major foods include small invertebrates, krill, capelin, herring, pollock, haddock, and other small shoaling fish (Jefferson et al., 2015; Kuker et al., 2005; Lindstrom and Haug, 2001). Minke whales are prey for killer whales (Ford et al., 2005); a minke was observed being attacked by killer whales near British Columbia (Weller, 2008).

Species Specific Threats

Serious injury or mortality from interactions with fishing gear poses a threat to minke whales.

4.7 Sperm Whale (*Physeter macrocephalus*)

The sperm whale is the only large whale that is an odontocete (toothed whale).

Status and Management

The sperm whale has been listed as endangered since 1970 under the precursor to the ESA, and is depleted under the MMPA. Sperm whales are divided into three stocks in the Pacific. Of these, the Hawaii stock occurs within the Study Area.

Geographic Range and Distribution

General. The sperm whale occurs in all oceans, ranging from the pack ice in both hemispheres to the equator. Primarily, this species is typically found in the temperate and tropical waters of the Pacific (Rice, 1989). This species appears to have a preference for deep waters (Jefferson et al., 2015). Typically, sperm whale concentrations correlate with areas of high productivity, including areas near drop offs and with strong currents and steep topography (Gannier and Praca, 2007; Jefferson et al., 2015).

Insular Pacific-Hawaiian Large Marine Ecosystem. Sperm whales occur in Hawaii waters and are one of the more abundant large whales found in that region (Baird et al., 2003b; Mobley et al., 2000).

Open Ocean. Sperm whales show a strong preference for deep waters (Rice, 1989; Whitehead, 2003). Their distribution is typically associated with waters over the continental shelf break, over the continental slope, and into deeper waters.

Sperm whales are somewhat migratory. General shifts occur during summer months for feeding and breeding, while in some tropical areas, sperm whales appear to be largely resident (Rice, 1989; Whitehead, 2003; Whitehead et al., 2008). Pods of females with calves remain on breeding grounds throughout the year, between 40° N and 45° N (Rice, 1989; Whitehead, 2003), while males migrate between low-latitude breeding areas and higher-latitude feeding grounds (Pierce et al., 2007). In the northern hemisphere, “bachelor” groups (males typically 15 to 21 years old and bulls [males] not taking part in reproduction) generally leave warm waters at the beginning of summer and migrate to feeding grounds that may extend as far north as the perimeter of the arctic zone. In fall and winter, most return south, although some may remain in the colder northern waters during most of the year (Pierce et al., 2007).

Population and Abundance

The abundance of sperm whales in the eastern tropical Pacific has been estimated as 22,700 individuals. The current best available abundance estimate for the Hawaii stock of sperm whales is 3,354 (CV = 0.34). Sperm whales are frequently identified via visual observation and hydrophones on the PMRF range (U.S. Department of the Navy, 2015).

Predator/Prey Interactions

Sperm whales are known to occur in groups for both predator defense and foraging purposes. Sperm whales feed on squid, other cephalopods, and bottom-dwelling fish and invertebrates (Davis et al., 2007; Marcoux et al., 2007; Rice, 1989). Exactly how sperm whales search for, detect, and capture their prey remains uncertain. False killer whales, pilot whales, and killer whales have been documented harassing and, on occasion, attacking sperm whales (Baird, 2009a).

Species Specific Threats

Sperm whales are susceptible to entanglement in fishing gear, ingestion of marine debris, and ship strikes.

4.8 Pygmy Sperm Whale (*Kogia breviceps*)

There are two species of *Kogia*: the pygmy sperm whale (*Kogia breviceps*) and the dwarf sperm whale (*Kogia sima*). Before 1966 they were considered to be the same species until morphological distinction was shown (Handley, 1966). Dwarf and pygmy sperm whales are difficult to distinguish from one another at sea, and many misidentifications have been made. Sightings of either species are often categorized as the genus *Kogia* (Jefferson et al., 2015).

Status and Management

The pygmy sperm whale is protected under the MMPA but is not listed under the ESA. Two stocks are identified in the Pacific Ocean. Of these, only the Hawaii stock occurs in the Study Area.

Geographic Range and Distribution

General. Pygmy sperm whales apparently occur close to shore, sometimes over the outer continental shelf. However, several studies have suggested that this species generally occurs beyond the continental shelf edge (Bloodworth and Odell, 2008; MacLeod et al., 2004). The pygmy sperm whale frequents more temperate habitats than the other *Kogia* species, which is more of a tropical species.

Insular Pacific-Hawaiian Large Marine Ecosystem. Sightings of pygmy sperm whales are rarely reported in Hawaii. During boat surveys between 2000 and 2003 in the Main Hawaiian Islands, this species was observed, but less commonly than the dwarf sperm whale (Baird, 2005; Baird et al., 2003b; Barlow et al., 2004). A freshly dead specimen was observed about 100 NM north of French Frigate Shoals during a 2010 survey. Pygmy sperm whales are one of the more commonly stranded species in the Hawaiian Islands, and this frequency of strandings indicates that the species is likely more common than sightings suggest (Maldini et al., 2005).

Open Ocean. Although deep oceanic waters may be the primary habitat for pygmy sperm whales, very few oceanic sightings offshore have been recorded within the Study Area. However, this may be because of the difficulty of detecting and identifying these animals at sea (Caldwell and Caldwell, 1989; Maldini et al., 2005). Records of this species from both the western (Japan) and eastern Pacific (California) suggest that the range of this species includes the North Pacific Central Gyre, and North Pacific Transition Zone (Carretta et al., 2010; Jefferson et al., 2015; Katsumata et al., 2004; Marten, 2000; Norman et al., 2004). Their range generally includes tropical and temperate warm water zones and is not likely to extend north into subarctic waters (Bloodworth and Odell, 2008; Jefferson et al., 2015).

Little is known about possible migrations of this species. No specific information regarding routes, seasons, or resighting rates in specific areas is available.

Population and Abundance

Few abundance estimates have been made for this species. Previously, based on results of a 2002 shipboard line-transect survey of the entire Hawaiian Islands EEZ, abundance was estimated as 7,138 individuals. However, NMFS no longer considers this information valid because it is out of date. There is no abundance estimate currently available. The frequency of strandings suggests pygmy sperm whales may not be as uncommon as sightings would suggest (Jefferson et al., 2015; Maldini et al., 2005).

Predator/Prey Interactions

Pygmy sperm whales feed on cephalopods and, less often, on deep-sea fishes and shrimps (Beatson, 2007; Caldwell and Caldwell, 1989). A recent study in Hawaiian waters showed cephalopods were the primary prey of pygmy sperm whales, making up 78.7 percent of prey abundance and 93.4 percent contribution by mass (West et al., 2009). Stomach samples revealed an extreme diversity of cephalopod prey, with 38 species from 17 different families (West et al., 2009). Pygmy sperm whales have not been documented to be prey to any other species although, similar to other whale species, they are likely subject to occasional killer whale predation.

Species Specific Threats

Pygmy sperm whales are susceptible to fisheries interactions.

4.9 Dwarf Sperm Whale (*Kogia sima*)

There are two species of *Kogia*, the pygmy sperm whale and the dwarf sperm whale, which had been considered to be the same species until recently. Genetic evidence suggests that there might also be two separate species of dwarf sperm whales globally, one in the Atlantic and one in the Indo-Pacific (Jefferson et al., 2015). Dwarf and pygmy sperm whales are difficult to distinguish from one another at sea, and many misidentifications have been made. Sightings of either species are often categorized as the genus *Kogia* (Jefferson et al., 2015).

Status and Management

The dwarf sperm whale is protected under the MMPA and is not listed under the ESA. NMFS has designated two stocks of dwarf sperm whales in the Pacific Ocean. Of these, the Hawaii stock occurs in the Study Area.

Geographic Range and Distribution

General. Dwarf sperm whales tend to occur over the outer continental shelf, and they may be relatively coastal in some areas with deep waters nearshore (MacLeod et al., 2004). Although the dwarf sperm whale appears to prefer more tropical waters than the pygmy sperm whale, the exact habitat preferences of the species are not well understood. Dwarf sperm whales have been observed in both outer continental shelf and more oceanic waters. Records of this species from both the western Pacific (Taiwan) and eastern Pacific (California) suggest that its range includes the southern portions of the California Current Large Marine Ecosystem, all waters of the North Pacific Central Gyre, the Insular Pacific-Hawaiian Large Marine Ecosystem, and the southern portion of the North Pacific Transition Zone (Carretta et al., 2010; Jefferson et al., 2015; Wang and Yang, 2006; Wang et al., 2001).

Insular Pacific-Hawaiian Large Marine Ecosystem. During vessel surveys between 2000 and 2003 in the Main Hawaiian Islands, this species was the sixth most commonly observed species, typically in deep water (up to 10,400 feet [3,169.9 m]) (Baird, 2005; Baird et al., 2003b; Barlow et al., 2004). Small boat surveys within the Main Hawaiian Islands since 2002 have documented dwarf sperm whales on 73 occasions, most commonly in water depths between 500 m and 1,000 m (Baird et al., 2013). Dwarf sperm whales are one of the more commonly stranded species in the Hawaiian Islands (Maldini et al., 2005), and the frequency of strandings indicates that the species is likely more common than sightings suggest.

Open Ocean. Although deep oceanic waters may be the primary habitat for this species, very few oceanic sightings offshore have occurred within the Study Area. The lack of sightings may be due to the difficulty of detecting and identifying these animals at sea (Jefferson et al., 2015; Maldini et al., 2005).

Population and Abundance

Results of a 2002 shipboard line-transect survey of the entire Hawaiian Islands EEZ indicated an abundance of 17,519 individuals. However, NMFS considers this information to be out of date and no longer valid. Accordingly, there is no abundance estimate currently available. The frequency of strandings suggests that dwarf sperm whales may not be as uncommon as sightings would suggest (Jefferson et al., 2015).

Predator/Prey Interactions

Dwarf sperm whales feed on cephalopods and, less often, on deep sea fishes and shrimps (Caldwell and Caldwell, 1989; Sekiguchi et al., 1992). Dwarf sperm whales generally forage near the seafloor (McAlpine, 2009). Killer whales are predators of dwarf sperm whales (Dunphy-Daly et al., 2008).

Species Specific Threats

There are no significant species-specific threats to dwarf sperm whales in the Study Area.

4.10 Killer Whale (*Orcinus orca*)

A single species of killer whale is currently recognized, but genetic and morphological evidence has led some cetacean biologists to consider the possibility of multiple species or subspecies worldwide. In the north Pacific, these forms are variously known as ‘‘residents,’’ ‘‘transients,” and “offshore” ecotypes (Hoelzel et al., 2007).

Status and Management

The killer whale is protected under the MMPA, and overall the species is not listed under the ESA (the southern resident population in Puget Sound, not found in the Study Area, is listed as endangered under the ESA and depleted under the MMPA). The AT1 transient stock is also depleted under the MMPA. In the Pacific Ocean, NMFS recognizes the AT1 Transient stock, four Eastern North Pacific stocks, the West Coast Transient stock, the Eastern North Pacific Offshore stock, and a Hawaii stock (Carretta et al., 2015). Only the Hawaii stock occurs in the Study Area.

Geographic Range and Distribution

General. Killer whales are found in all marine habitats from the coastal zone (including most bays and inshore channels) to deep oceanic basins and from equatorial regions to the polar pack ice zones of both hemispheres. Although killer whales are also found in tropical waters and the open ocean, they are most numerous in coastal waters and at higher latitudes (Dahlheim and Heyning, 1999). The range of this species is known to include the Insular Pacific-Hawaiian Large Marine Ecosystem, the North Pacific Gyre, and North Pacific Transition Zone.

Insular Pacific-Hawaiian Large Marine Ecosystem. Although killer whales apparently prefer cooler waters, they have been observed in Hawaiian waters (Barlow, 2006; Shallenberger, 1981). Sightings are extremely infrequent in Hawaiian waters, and typically occur during winter, suggesting those sighted are seasonal migrants (Baird et al., 2003a; Mobley et al., 2001a). Baird (2006) documented 21 sightings of killer whales within the Hawaiian Islands EEZ, primarily around the Main Hawaiian Islands. Summer/fall surveys of the Hawaiian Islands EEZ resulted in one sighting (Bradford et al., 2013). Killer whales are occasionally sighted off Kauai (e.g., Cascadia Research, 2012a). There are also documented strandings for this species from the Hawaiian Islands (Maldini et al., 2005).

Open Ocean. This species is known to occur in deep oceanic waters off Hawaii and elsewhere in the Pacific (Carretta et al., 2010; Miyashita et al., 1996; Wang et al., 2001). In the eastern tropical Pacific, killer whales are known to occur from offshore waters of San Diego to Hawaii and south to Peru (Barlow, 2006; Ferguson, 2005). Offshore killer whales are known to inhabit both the western and eastern temperate Pacific and likely have a continuous distribution across the north Pacific (Steiger et al., 2008).

In most areas of their range, killer whales do not show movement patterns that would be classified as traditional migrations. However, there are often seasonal shifts in density, both onshore/offshore and north/south.

Population and Abundance

The current best available abundance estimate for the Hawaii stock, based on a 2010 shipboard survey of the entire Hawaiian Islands EEZ, is 101 (CV = 1.00) killer whales.

Predator/Prey Interactions

Killer whales feed on a variety of prey, including bony fishes, elasmobranchs (a class of fish composed of sharks, skates, and rays), cephalopods, seabirds, sea turtles, and other marine mammals (Fertl et al., 1996; Jefferson et al., 2015). Some populations are known to specialize in specific types of prey (Jefferson et al., 2015; Krahn et al., 2004; Wade et al., 2009). The killer whale has no known natural predators; it is considered to be the top predator of the oceans (Ford, 2008).

Species Specific Threats

Boat traffic has been shown to affect the behavior of the endangered southern resident killer whale population around San Juan Island, Washington (Lusseau et al., 2009). In the presence of boats, whales were significantly less likely to be foraging and significantly more likely to be traveling (Lusseau et al., 2009). These changes in behavior were particularly evident when boats were within 330 feet (100 m) of the whales. While this population of killer whales is not present in the Study Area, their behavior may be indicative of other killer whale populations that are present.

Another issue that has been recognized as a potential threat to the endangered southern resident killer whale population is the potential reduction in prey, particularly Chinook salmon (Ford et al., 2009). As noted above, while this population of killer whales is not present in the Study Area, prey reduction may be a threat to other killer whale populations as well. Additionally, killer whales may be particularly susceptible to interactions with fisheries including entanglement.

4.11 False Killer Whale (*Pseudorca crassidens*)

Status and Management

Not much is known about most false killer whale populations globally, but the species is known to be present in Hawaiian waters. NMFS currently recognizes a Hawaiian Islands Stock Complex, which includes the Hawaii Pelagic stock, the Northwestern Hawaiian Islands stock, and the Main Hawaiian Islands insular stock. All stocks of false killer whales are protected under the MMPA. The Main Hawaiian Islands insular stock (considered resident to the Main Hawaiian Islands consisting of Kauai, Oahu, Molokai, Lanai, Kahoolawe, Maui, and Hawaii) is listed as endangered under the ESA and as depleted under the MMPA. The historic decline of this stock has been the result of various factors including small population size, evidence of decline of the local Hawaii stock, and incidental take by commercial fisheries (Oleson et al., 2010). It is estimated that approximately eight false killer whales from the Main Hawaiian Islands insular and Hawaii Pelagic stocks are killed or seriously injured by commercial longline fisheries each year (McCracken and Forney, 2010). This number is most likely an underestimate since it does not include any animals that were unidentified and might have been false killer whales. Due to evidence of a serious decline in the population (Reeves et al., 2009), a Take Reduction Team (a team of experts to study the specific topic, also referred to as a Biological Reduction Team) was formed by NOAA in 2010 as required by the MMPA. As a result of the Take Reduction Team's activities, a Take Reduction Plan was published in 2012. The Plan identifies regulatory and non-regulatory measures designed to reduce mortalities and serious injuries of false killer whales that are associated with Hawaii long-line fisheries.

The NMFS considers all false killer whales found within 72 km (39 NM) of each of the Main Hawaiian Islands as part of the Main Hawaiian Islands Insular stock. In the vicinity of the Main Hawaiian Islands, the Hawaii Pelagic stock is considered to inhabit waters greater than 11 km (6 NM) from shore. There is no inner boundary for the Hawaii Pelagic stock within the Northwestern Hawaiian Islands. Animals belonging to the Northwestern Hawaiian Islands stock are considered to inhabit waters within a 93 km (50 NM) radius of the Northwestern Hawaiian Islands, or the boundary of the Papahānaumokuākea Marine National Monument, with the radial boundary extended to the southeast to encompass Kauai and Niihau. NMFS recognizes that there is geographic overlap between the stocks in some areas. In particular, individuals from the Northwestern Hawaiian Islands and Hawaii Pelagic stocks have potential for occurrence at the Long Range Strike WSEP impact location. This overlap precludes analysis of differential impact between the two stocks based on spatial criteria.

The density data used in the Navy's modeling and analyses were derived from habitat-based density models for the combined stocks, since limited sighting data did not allow for stock-specific models (Becker et al., 2012). Habitat-based density models allow predictions of cetacean densities on a finer spatial scale than traditional analyses (Barlow et al., 2009) and are thus better suited for spatially explicit effects analyses. In the most recent stock assessment report, separate abundance numbers are provided for each stock of the false killer whale Hawaiian Islands Stock Complex.

Geographic Range and Distribution

General. The range of this species is known to include waters of the Insular Pacific-Hawaiian Large Marine Ecosystems and the North Pacific Gyre.

Insular Pacific-Hawaiian Large Marine Ecosystem. The false killer whale is regularly found within Hawaiian waters and has been reported in groups of up to 100 (Shallenberger, 1981; Baird et al., 2003a). A handful of stranding records exists in the Hawaiian Islands (Maldini et al., 2005). Distribution of Main Hawaiian Islands insular false killer whales has been assessed using data from visual surveys and satellite tag data. Tagging data from seven groups of individuals tagged off the islands of Hawaii and Oahu indicate that the whales move rapidly and semi-regularly throughout the Main Hawaiian Islands and have been documented as far as 112 km offshore over a total range of 31,969 square miles (mi^2) (82,800 square kilometers [km^2]) (Baird et al., 2012). Baird et al. (2012) note, however, that limitations in the sampling "suggest the range of the population is likely underestimated, and there are probably other high-use areas that have not been identified." Photo identification studies also document that the animals regularly use both leeward and windward sides of the islands (Baird et al., 2005a; Baird, 2009a; Baird et al., 2010b; Forney et al., 2010; Baird et al., 2012). Some individual false killer whales tagged off the island of Hawaii have remained around that island for extended periods (days to weeks), but individuals from all tagged groups eventually were found broadly distributed throughout the Main Hawaiian Islands (Baird, 2009a; Forney et al., 2010). Individuals utilize habitat over varying water depths from less than 164 feet (50 m) to greater than 13,123 feet (4,000 m) (Baird et al., 2010b). It has been hypothesized that inter-island movements may depend on the density and movement patterns of their prey species (Baird, 2009a).

Open Ocean. In the north Pacific, this species is known to occur in deep oceanic waters off Hawaii and elsewhere in the Pacific (Carretta et al., 2010; Miyashita et al., 1996; Wang et al., 2001). False killer whales are not considered a migratory species, although seasonal shifts in density likely occur. Seasonal movements in the western north Pacific may be related to prey distribution (Odell and McClune, 1999). Satellite-tracked individuals around the Hawaiian Islands indicate that false killer whales can move extensively among different islands and also sometimes move from an island coast to as far as 60 miles. (96.6 km) offshore (Baird, 2009a; Baird et al., 2010b).

Population and Abundance

False killer whales found in waters surrounding the Main Hawaiian Islands are known to be genetically separate from the population in the outer part of the Hawaiian Islands EEZ and the central tropical Pacific (Chivers et al., 2007; Reeves et al., 2009). Recent genetic research by Chivers et al. (2010) indicates that the Main Hawaiian Islands insular and Hawaii Pelagic populations of false killer whales are independent and do not interbreed. The current abundance estimate of the Main Hawaiian Islands insular stock is 151 individuals (CV = 0.20), the Hawaii Pelagic stock is 1,540 individuals (CV = 0.66), and the Northwestern Hawaiian Islands stock is 617 individuals (CV = 1.11).

Reeves et al. (2009) summarized information on false killer whale sightings near Hawaii between 1989 and 2007, based on various survey methods, and suggested that the Main Hawaiian Islands stock may have declined during the last two decades. Baird (2009a) reviewed trends in sighting rates of false killer whales from aerial surveys conducted using consistent methodology around the Main Hawaiian Islands between 1994 and 2003. Sighting rates during these surveys exhibited a significant decline that could not be attributed to any weather or methodological changes. Data are currently insufficient to determine population trends for the Northwestern Hawaiian Islands or Hawaii Pelagic stocks (Carretta et al., 2015).

Predator/Prey Interactions

False killer whales feed primarily on deep-sea cephalopods and fish (Odell and McClune, 1999). They may prefer large fish species, such as mahi mahi and tunas. Twenty-five false killer whales that stranded off the coast of the Strait of Magellan were examined and found to feed primarily on cephalopods and fish. Squid beaks were found in nearly half of the stranded animals. The most important prey species were found to be the squid species, *Martialiabyadesi* and *Illex argentinus,* followed by the coastal fish, *Macruronus magellanicus* (Alonso et al., 1999). False killer whales have been observed to attack other cetaceans, including dolphins and large whales such as humpback and sperm whales (Baird, 2009b). They are known to behave aggressively toward small cetaceans in tuna purse seine nets. Unlike other whales or dolphins, false killer whales frequently pass prey back and forth among individuals before they start to eat the fish, in what appears to be a way of affirming social bonds (Baird et al., 2010b). This species is believed to be preyed on by large sharks and killer whales (Baird, 2009b). Like many marine mammals, false killer whales accumulate high levels of toxins in their blubber over the course of their long lives. Because they feed on large prey at the top of the food chain (e.g., squid, tunas) they may be impacted by competition with fisheries (Cascadia Research, 2010).

Species Specific Threats

In Hawaiian waters, false killer whales are particularly susceptible to fishery interactions and entanglements (Forney et al., 2010).

4.12 Pygmy Killer Whale (*Feresa attenuata*)

The pygmy killer whale is often confused with the false killer whale and melon-headed whale, which are similar in overall appearance.

Status and Management

The pygmy killer whale is protected under the MMPA and is not listed under the ESA. For the MMPA stock assessment reports, there is a single Pacific management stock including animals found within the Hawaiian Islands EEZ and in adjacent high seas waters. However, due to lack of data regarding abundance, distribution, and impacts for high seas waters, the status of the stock is evaluated based only on occurrence in waters of the Hawaiian Islands EEZ.

Geographic Range and Distribution

General. The pygmy killer whale is generally an open ocean deepwater species (Davis et al., 2000; Wursig et al., 2000).

Insular Pacific-Hawaiian Large Marine Ecosystem. Although rarely seen in nearshore waters, sightings have been relatively frequent in the Insular Pacific-Hawaiian Large Marine Ecosystem (Barlow et al., 2004; Donahue and Perryman, 2008; Pryor et al., 1965; Shallenberger, 1981; Smultea et al., 2007). A line-transect survey conducted in February 2009 by the Cetacean Research Program surrounding the Hawaiian Islands resulted in the sighting of one pygmy killer whale (Oleson and Hill, 2009). Shipboard surveys in the Hawaiian Islands EEZ in 2002 and 2010 resulted in a total of eight additional sightings (Barlow, 2006; Bradford et al., 2013). Six strandings have been documented from Maui and the Island of Hawaii (Carretta et al., 2010; Maldini et al., 2005).

Open Ocean. This species' range in the open ocean generally extends to the southern regions of the North Pacific Gyre and the southern portions of the North Pacific Transition Zone. Many sightings have occurred from cetacean surveys of the eastern tropical Pacific (Au and Perryman, 1985; Barlow and Gisiner, 2006; Wade and Gerrodette, 1993). This species is also known to be present in the western Pacific (Wang and Yang, 2006). Its range is generally considered to be south of 40° N and continuous across the Pacific (Donahue and Perryman, 2008; Jefferson et al., 2015). Migrations or seasonal movements are not known.

Population and Abundance

Although the pygmy killer whale has an extensive global distribution, it is not known to occur in high densities in any region and thus is probably one of the least abundant of the pantropical delphinids. The current best available abundance estimate for the pygmy killer whale derives from a 2010 shipboard survey of the Hawaiian Islands EEZ; the estimate was 3,433 individuals (CV = 0.52) (Bradford et al., 2013).

Predator/Prey Interactions

Pygmy killer whales feed predominantly on fish and squid. They have been known to attack other dolphin species, apparently as prey, although this is not common (Jefferson et al., 2015; Perryman and Foster, 1980; Ross and Leatherwood, 1994). The pygmy killer whale has no documented predators (Weller, 2008). However, like other cetaceans, it may be subject to predation by killer whales.

Species Specific Threats

Fisheries interactions are likely as evidenced by a pygmy killer whale that stranded on Oahu with signs of hooking injury (NMFS, 2007a) and the report of mouthline injuries noted in some individuals (Baird unpublished data cited in Carretta et al., 2011). It has been suggested that pygmy killer whales may be particularly susceptible to loud underwater sounds, such as active sonar and seismic operations, based on the stranding of pygmy killer whales in Taiwan (Wang and Yang, 2006). However, this suggestion is probably not supported by the data available.

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

Status and Management

Short-finned pilot whales are protected under the MMPA and are not listed under the ESA. For MMPA stock assessment reports, short-finned pilot whales within the Pacific U.S. EEZ are divided into two discrete areas: (1) waters off California, Oregon and Washington, and (2) Hawaiian waters. The short-finned pilot whale is widely distributed throughout most tropical and warm temperate waters of the world.

Geographic Range and Distribution

General. A number of studies in different regions suggest that the distribution and seasonal inshore/offshore movements of pilot whales coincide closely with the abundance of squid, their preferred prey (Bernard and Reilly, 1999; Hui, 1985; Payne and Heinemann, 1993). This species' range generally extends to the southern regions of the North Pacific Gyre and the California Current and Insular Pacific-Hawaiian Large Marine Ecosystems. Many sightings have occurred from cetacean surveys of the eastern tropical Pacific, where the species is reasonably common (Au and Perryman, 1985; Barlow, 2006; Wade and Gerrodette, 1993).

Insular Pacific-Hawaiian Large Marine Ecosystem. Short-finned pilot whales are known to occur in waters surrounding the Hawaiian Islands (Barlow, 2006; Shallenberger, 1981; Smultea et al., 2007). They are most commonly observed around the Main Hawaiian Islands, are relatively abundant around Oahu and the Island of Hawaii, and are also present around the Northwestern Hawaiian Islands (Barlow, 2006; Maldini Feinholz, 2003; Shallenberger, 1981). Fourteen strandings of this species have been recorded at the Main Hawaiian Islands, including five mass strandings (Carretta et al., 2010; Maldini et al., 2005). Short-finned pilot whales were detected in nearshore waters off the western shore of Kauai during passive acoustic and visual surveys in 2014.

Open Ocean. The short-finned pilot whale occurs mainly in deep offshore areas; thus, the species occupies waters over the continental shelf break, in slope waters, and in areas of high topographic relief (Olson, 2009). While pilot whales are typically distributed along the continental shelf break, movements over the continental shelf are commonly observed in the northeastern United States (Payne and Heinemann, 1993) and close to shore at oceanic islands, where the shelf is narrow and deeper waters are found nearby (Gannier, 2000; Mignucci-Giannoni, 1998). Short-finned pilot whales are not considered a migratory species, although seasonal shifts in abundance have been noted in some portions of the species' range.

Population and Abundance

A 2010 shipboard survey of the entire Hawaiian Islands EEZ resulted in an abundance estimate of 12,422 (CV = 0.43) short-finned pilot whales and is considered to be the best available estimate (Bradford et al., 2013).

Predator/Prey Interactions

Pilot whales feed primarily on squid but also take fish (Bernard and Reilly, 1999). They are generally well adapted to feeding on squid (Jefferson et al., 2015; Werth, 2006a; Werth, 2006b). Pilot whales are not generally known to prey on other marine mammals, but records from the eastern tropical Pacific suggest that the short-finned pilot whale does occasionally chase and attack, and may eat, dolphins during fishery operations (Olson, 2009; Perryman and Foster, 1980). They have also been observed harassing sperm whales in the Gulf of Mexico (Weller et al., 1996).

This species is not known to have any predators (Weller, 2008). It may be subject to predation by killer whales.

Species Specific Threats

Short-finned pilot whales are particularly susceptible to fisheries interactions and entanglement.

4.14 Melon-headed Whale (*Peponocephala electra*)

This small tropical dolphin species is similar in appearance to the pygmy killer whale.

Status and Management

The melon-headed whale is protected under the MMPA and is not listed under the ESA. NMFS has identified a Hawaiian Islands Stock Complex, which consists of Hawaiian Islands and Kohala Resident stocks. The Kohala resident stock includes melon-headed whales off the Kohala Peninsula and west coast of Hawaii Island, in waters less than 2,500 m depth. These whales would not be expected in the Study Area. The Hawaiian Islands stock includes whales occurring throughout the Hawaiian Islands EEZ (including the area of the Kohala resident stock) and adjacent high seas waters. Due to a lack of data, stock evaluation is based on whales in the Hawaiian Islands EEZ only. In addition, in the area of overlap between the two stocks, individual animals can currently only be distinguished by photographic identification.

Geographic Range and Distribution

General. Melon-headed whales are found worldwide in tropical and subtropical waters. They have occasionally been reported at higher latitudes, but these movements are considered to be beyond their normal range because the records indicate these movements occurred during incursions of warm water currents (Perryman et al., 1994). The range of this species is known to include waters of the Insular Pacific-Hawaiian Large Marine Ecosystems and the North Pacific Gyre (Jefferson et al., 2015; Perryman, 2008). In the north Pacific, occurrence of this species is well known in deep waters off many areas, including Hawaii (Au and Perryman, 1985; Carretta et al., 2010; Ferguson, 2005; Perrin, 1976; Wang et al., 2001).

Insular Pacific-Hawaiian Large Marine Ecosystem. The melon-headed whale is regularly found within Hawaiian waters (Baird et al., 2003a; Baird et al., 2003b; Mobley et al., 2000; Shallenberger, 1981). Large groups are seen regularly, especially off the Waianae coast of Oahu, the north Kohala coast of Hawaii, and the leeward coast of Lanai (Baird, 2006; Shallenberger, 1981). A line-transect survey conducted in February 2009 by the Cetacean Research Program surrounding the Hawaiian Islands resulted in the sighting of one melon-headed whale (Oleson and Hill, 2009). Similarly, a shipboard survey of the entire Hawaiian Islands EEZ in 2010 resulted in one sighting (Bradford et al., 2013). A total of 14 stranding records exist for this species in the Hawaiian Islands (Carretta et al., 2010; Maldini et al., 2005).

Open Ocean. Melon-headed whales are most often found in offshore deep waters but sometimes move close to shore over the continental shelf. Brownell et al. (2009) found that melon-headed whales near oceanic islands rest near shore during the day, and feed in deeper waters at night. The melon-headed whale is not known to migrate.

Population and Abundance

As described in the most recent stock assessment report (Carretta et al., 2015), the current best available abundance estimate for the Hawaiian Islands stock of melon-headed whale is 5,794 (CV = 0.20). The abundance estimate for the Kohala resident stock is 447 individuals (CV = 0.12).

Predator/Prey Interactions

Melon-headed whales prey on squid, pelagic fishes, and occasionally crustaceans. Most of the fish and squid families eaten by this species consist of mid-water forms found in waters up to 4,920 feet (1,500 m) deep, suggesting that feeding takes place deep in the water column (Jefferson and Barros, 1997). Melon-headed whales are believed to be preyed on by killer whales and have been observed fleeing from killer whales in Hawaiian waters (Baird et al., 2006a).

Species Specific Threats

There are no significant species-specific threats to melon-headed whales in Hawaii, although it is likely that they are susceptible to fisheries interactions.

4.15 Bottlenose Dolphin (*Tursiops truncatus*)

The classification of the genus *Tursiops* continues to be in question; two species are recognized, the common bottlenose dolphin (*Tursiops truncatus*) and the Indo-Pacific bottlenose dolphin (*Tursiops aduncus*) (Rice, 1998), though additional species are likely to be recognized with future analyses (Natoli et al., 2004).

Status and Management

The bottlenose dolphin is protected under the MMPA and is not listed under the ESA. For the MMPA stock assessment reports, multiple bottlenose dolphin stocks are designated within the Pacific U.S. EEZ. However, within the region of the Study Area, NMFS has identified five stocks that comprise the bottlenose dolphin Hawaiian Islands Stock Complex: (1) Hawaii Pelagic, (2) Kauai/ Niihau, (3) Oahu, (4) the 4-Island region, and (5) Hawaii Island. The most recent stock assessment report (Carretta et al., 2015) indicates that demographically independent populations likely exist in the Northwestern Hawaiian Islands. However, data is currently insufficient to delineate such stocks, and bottlenose dolphins in this portion of Hawaii are included in the Hawaii Pelagic stock (Carretta et al., 2015).

Geographic Range and Distribution

General. Common bottlenose dolphins are found most commonly in coastal and continental shelf waters of tropical and temperate regions of the world. They occur in most enclosed or semi-enclosed seas. The species inhabits shallow, murky, estuarine waters and also deep, clear offshore waters in oceanic regions (Jefferson et al., 2015; Wells et al., 2009). Common bottlenose dolphins are often found in bays, lagoons, channels, and river mouths and are known to occur in very deep waters of some ocean regions. The range of this species is known to include waters of the Insular Pacific-Hawaiian Large Marine Ecosystems, the North Pacific Gyre, and the North Pacific Transition Zone (Au and Perryman, 1985; Carretta et al., 2010; Miyashita, 1993; Wang and Yang, 2006).

Insular Pacific-Hawaiian Large Marine Ecosystem. Common bottlenose dolphins are common throughout the Hawaiian Islands, and they are typically observed throughout the main islands and from the Island of Hawaii to Kure Atoll within 5 miles (8.05 km) of the coast (Baird et al., 2009a; Shallenberger, 1981). In the Hawaiian Islands, this species is found in both shallow coastal waters and deep offshore waters (Baird et al., 2003b). The offshore variety is typically larger than the inshore. Twelve stranding records from the Main Hawaiian Islands exist (Maldini et al., 2005; Maldini Feinholz, 2003). Common bottlenose dolphin vocalizations have been documented during acoustic surveys, and the species has been commonly sighted during aerial surveys in the Hawaiian Islands (Barlow et al., 2008; Barlow et al., 2004; Mobley et al., 2000). Bottlenose dolphins were detected in nearshore waters off the western shore of Kauai during passive acoustic and visual surveys in 2014.

Open Ocean. In the eastern tropical Pacific and elsewhere, open ocean populations occur far from land. However, population density appears to be higher in nearshore areas (Scott and Chivers, 1990). In the north Pacific, common bottlenose dolphins have been documented in offshore waters as far north as about 41° N (Carretta et al., 2010). Although in most areas bottlenose dolphins do not migrate (especially where they occur in bays, sounds, and estuaries), seasonal shifts in abundance do occur in many areas (Griffin and Griffin, 2004).

Population and Abundance

The current best available abundance estimate of the Hawaiian Islands Stock Complex of common bottlenose dolphins comes from a ship survey of the entire Hawaiian Islands EEZ in 2010 (Bradford et al., 2013). The resulting abundance estimates for the various stocks are as follows: (1) Hawaii Pelagic - 5,794 individuals (CV = 0.59); (2) Kauai and Niihau – 147 individuals (CV = 0.11); (3) Oahu – 594 individuals (CV = 0.54); (4) 4-Island Region – 153 individuals (CV = 0.24); and (5) Hawaii Island – 102 individuals (CV = 0.13).

The criteria and thresholds developed by the Navy and NMFS result in consideration of potential impacts at distances ranging from immediately adjacent to the activity (meters) to tens of kilometers from some acoustic stressors. Therefore, the abundance estimates and generalized boundaries and locations for bottlenose dolphins stocks in Hawaii are insufficient to allow for an analysis of impacts on individual stocks, and they are treated as a group and discussed in terms of the Hawaiian Islands Stock Complex.

Predator/Prey Interactions

These animals are opportunistic feeders, taking a wide variety of fishes, cephalopods, and shrimps (Wells and Scott, 1999), and using a variety of feeding strategies (Shane, 1990). In addition to using echolocation, a process for locating prey by emitting sound waves that reflect back, bottlenose dolphins likely detect and orient to fish prey by listening for the sounds their prey produce (so-called passive listening) (Barros and Myrberg, 1987; Barros and Wells, 1998). Nearshore bottlenose dolphins prey predominantly on coastal fish and cephalopods, while offshore individuals prey on open ocean cephalopods and a large variety of near-surface and mid-water fish species (Mead and Potter, 1995). Throughout its range, this species is known to be preyed on by killer whales and sharks (Wells and Scott, 2008).

Species Specific Threats

Common bottlenose dolphins are particularly susceptible to entanglement and other interactions with fishery operations.

4.16 Pantropical Spotted Dolphin (*Stenella attenuata*)

Status and Management

The species is protected under the MMPA and is not listed under the ESA. For the MMPA stock assessment reports, NMFS has identified four stocks that compose the pantropical spotted dolphin Hawaiian Islands Stock Complex: (1) Hawaii Pelagic, (2) Oahu, (3) the 4-Island region, and (4) Hawaii Island.

Geographic Range and Distribution

General. The pantropical spotted dolphin is distributed in offshore tropical and subtropical waters of the Pacific, Atlantic, and Indian Oceans between about 40° N and 40° S (Baldwin et al., 1999; Perrin, 2008b). The species is much more abundant in the lower latitudes of its range. It is found mostly in deeper offshore waters but does approach the coast in some areas (Jefferson et al., 2015; Perrin, 2001).

Insular Pacific-Hawaiian Large Marine Ecosystem. Based on known habitat preferences and sighting data, the primary occurrence for the pantropical spotted dolphin in the Insular Pacific-Hawaiian Large Marine Ecosystem is between 330 and 13,122 feet (100.6 to 3,999.6 m) depth. This area of primary occurrence also includes a continuous band connecting all the Main Hawaiian Islands, Nihoa, and Kaula, taking into account possible inter-island movements. Secondary occurrence is expected from the shore to 330 feet (100.6 m), as well as seaward of 13,120 feet (3,998.9 m). Pantropical spotted dolphins make up a relatively large portion of odontocete sightings around Oahu, the 4-Islands, and the Island of Hawaii (about one-fourth of total sightings); however, they are largely absent from nearshore waters around Kauai and Niihau (about four percent of sightings) (Baird et al., 2013).

Open Ocean. In the open ocean, this species ranges from 25° N (Baja California, Mexico) to 17° South (S) (southern Peru) (Perrin and Hohn, 1994). Pantropical spotted dolphins are associated with warm tropical surface water in the eastern tropical Pacific (Au and Perryman, 1985; Reilly, 1990). Au and Perryman (1985) noted that the species occurs primarily north of the Equator, off southern Mexico, and westward along 10° N.

Although pantropical spotted dolphins do not migrate, extensive movements are known in the eastern tropical Pacific (although these have not been strongly linked to seasonal changes) (Scott and Chivers, 2009).

Population and Abundance

Morphological and coloration differences and distribution patterns have been used to establish that the spotted dolphins around Hawaii belong to a stock that is distinct from those in the eastern tropical Pacific (Carretta et al., 2010). Based on shipboard surveys of the Hawaiian Islands EEZ, the current best available abundance estimate of the Hawaii Pelagic stock of the Hawaiian Islands Stock Complex is 15,917 individuals (CV = 0.40). There is currently insufficient information to provide abundance estimates for the remaining three stocks (Oahu, 4-Island Region, and Hawaii Island).

Predator/Prey Interactions

Pantropical spotted dolphins prey on near-surface fish, squid, and crustaceans, and on some mid-water species (Perrin and Hohn, 1994). Results from various tracking and food habit studies suggest that pantropical spotted dolphins off Hawaii feed primarily at night on surface and mid-water species that rise with the deep scattering layer toward the water's surface after dark (Baird et al., 2001; Robertson and Chivers, 1997). Pantropical spotted dolphins may be preyed on by killer whales and sharks, and have been observed fleeing killer whales in Hawaiian waters (Baird et al., 2006a). Other predators may include the pygmy killer whale, false killer whale, and occasionally the short-finned pilot whale (Perrin, 2008b).

Species Specific Threats

Although information on fishery-related impacts to cetaceans in Hawaiian waters is limited, the gear types used result in marine mammal mortality and injury in other fisheries throughout U.S. waters, and pantropical spotted dolphins in the Hawaii region are likely impacted to some degree as well. The most recent stock assessment report (Carretta et al., 2015) describes both anecdotal and documented negative interactions with fishing activities. Pantropical spotted dolphins located in the eastern tropical Pacific have had high mortality rates associated with the tuna purse seine fishery (Wade, 1994).

4.17 Striped Dolphin (*Stenella coeruleoalba*)

Status and Management

This species is protected under the MMPA and is not listed under the ESA. In the western north Pacific, three migratory stocks are recognized. In the eastern Pacific, NMFS divides striped dolphin management stocks within the U.S. EEZ into two separate areas: waters off California, Oregon, and Washington; and waters around Hawaii.

Geographic Range and Distribution

General. Although primarily a warm-water species, the range of the striped dolphin extends higher into temperate regions than those of any other species in the genus *Stenella*. Striped dolphins also are generally restricted to oceanic regions and are seen close to shore only where deep water approaches the coast. In some areas (e.g., the eastern tropical Pacific), they are mostly associated with convergence zones and regions of upwelling (Au and Perryman, 1985; Reilly, 1990). The northern limits are the Sea of Japan, Hokkaido, Washington State, and along roughly 40° N across the western and central Pacific (Reeves et al., 2002). In the eastern tropical Pacific, striped dolphins inhabit areas with large seasonal changes in surface temperature and thermocline depth, as well as seasonal upwelling (Au and Perryman, 1985; Reilly, 1990). In some areas, this species appears to avoid waters with sea temperatures less than 68° Fahrenheit (20° Celsius) (Van Waerebeek et al., 1998).

Insular Pacific-Hawaiian Large Marine Ecosystem. The striped dolphin regularly occurs around the Insular Pacific-Hawaiian Large Marine Ecosystem, although sightings are relatively infrequent there (Carretta et al., 2010). Summer/fall shipboard surveys of the Hawaiian Islands EEZ in 2002 and 2010 resulted in 15 and 29 sighting, respectively (Barlow, 2006; Bradford et al., 2013). The species occurs primarily seaward at a depth of about 547 feet (1,000 m), based on sighting records and the species' known preference for deep waters. Striped dolphins are occasionally sighted closer to shore in Hawaii, so an area of secondary occurrence is expected from a depth range of 55 to 547 feet (100 to 1,000 m). Occurrence patterns are assumed to be the same throughout the year (Mobley et al., 2000).

Open Ocean. The primary range of the striped dolphin includes the eastern and western waters of the North Pacific Transition Zone (Perrin et al., 1994a). The species is non-migratory in the Study Area.

Population and Abundance

The best available estimate of abundance for the Hawaii stock of the striped dolphin, based on the 2010 shipboard surveys described above, is 20,650 individuals (CV = 0.36).

Predator/Prey Interactions

Striped dolphins often feed in open sea or sea bottom zones along the continental slope or just beyond it in oceanic waters. Most of their prey possess light-emitting organs, suggesting that striped dolphins may be feeding at great depths, possibly diving to 655 to 2,295 feet (200 to 700 m) (Archer and Perrin, 1999). Striped dolphins may feed at night in order to take advantage of the deep scattering layer's diurnal vertical movements. Small mid-water fishes (in particular lanternfishes) and squids are the predominant prey (Perrin et al., 1994a). This species has been documented to be preyed upon by sharks (Ross, 1971). It may also be subject to predation by killer whales.

Species Specific Threats

There are no significant species-specific threats to striped dolphins in the Study Area.

4.18 Spinner Dolphin (*Stenella longirostris*)

Six morphotypes within four subspecies of spinner dolphins have been described worldwide in tropical and warm-temperate waters, including *Stenella longirostris longirostris* (Gray's, or pantropical, spinner dolphin), *Stenella longirostris orientalis* (eastern spinner dolphin), *Stenella longirostris centroamericana* (Central American spinner dolphin), and *Stenella longirostris roseiventris* (dwarf spinner dolphin) (Perrin et al., 2009). The Gray's spinner dolphin is the most widely distributed and is the subspecies that occurs in the Study Area. Hawaiian spinner dolphins belong to a stock that is separate from animals in the eastern tropical Pacific.

Status and Management

The spinner dolphin is protected under the MMPA and the species is not listed under the ESA. Although the eastern spinner dolphin (*Stenella longirostris orientalis*) is listed as depleted under the MMPA, the Gray's spinner dolphin, which occurs in the Study Area, is not designated as depleted. NMFS has identified six stocks that compose the spinner dolphin Hawaiian Islands Stock Complex: (1) Hawaii Pelagic, (2) Hawaii Island, (3) Oahu and 4-Island, (4) Kauai and Niihau, (5) Midway Atoll/Kure, and (6) Pearl and Hermes Reef. The Hawaii Pelagic stock includes animals found both within the Hawaiian Islands EEZ (but outside of island-associated boundaries) and in adjacent international waters. Based on an analysis of individual spinner dolphin movements, no dolphins have been found farther than 10 NM from shore and few individuals move long distances (from one main Hawaiian Island to another) (Hill et al., 2011).

Geographic Range and Distribution

General. Spinner dolphins occur in both oceanic and coastal environments. Most sightings have been associated with inshore waters, islands, or banks (Perrin and Gilpatrick, 1994). Open ocean populations, such as those in the eastern tropical Pacific, often are found in waters with a shallow thermocline (rapid temperature difference with depth) (Au and Perryman, 1985; Perrin, 2008c; Reilly, 1990). The thermocline concentrates open sea organisms in and above it, which spinner dolphins feed on. In the eastern tropical Pacific, spinner dolphins are associated with tropical surface waters typified by extensive stable thermocline ridging and relatively little annual variation in surface temperature (Au and Perryman, 1985; Perrin, 2008c). Coastal populations are usually found in island archipelagos, where they are associated with coastal trophic and habitat resources (Norris and Dohl, 1980; Poole, 1995).

Insular Pacific-Hawaiian Large Marine Ecosystem. In the Hawaiian Islands, spinner dolphins occur along the leeward coasts of all the major islands and around several of the atolls northwest of the Main Hawaiian Islands. Long-term site fidelity has been noted for spinner dolphins along the Kona coast of Hawaii, and along Oahu (Marten and Psarakos, 1999; Norris et al., 1994). Navy monitoring for the Rim of the Pacific Exercise in 2006 resulted in daily sightings of spinner dolphins within the offshore area of Kekaha Beach, Kauai, near the PMRF (U.S. Department of the Navy, 2006).

Spinner dolphins occur year round throughout the Insular Pacific-Hawaiian Large Marine Ecosystem, with primary occurrence from the shore to the 13,122 feet (3,999.6 m) depth. This takes into account offshore resting habitat and offshore feeding areas. Spinner dolphins are expected to occur in shallow water resting areas (about 162 feet [49.4 m] deep or less) throughout the middle of the day, moving into deep waters offshore during the night to feed. Primary resting areas are along the west side of Hawaii, including Makako Bay, Honokohau Bay, Kailua Bay, Kealakekua Bay, Honaunau Bay, and Kauhako Bay, and off Kahena on the southeast side of the island (Östman-Lind et al., 2004). Along the Waianae coast of Oahu, Hawaii, spinner dolphins rest along Makua Beach, Kahe Point, and Pokai Bay during the day (Lammers, 2004). Kilauea Bay on Kauai is also a popular resting bay for Hawaiian spinner dolphins (U.S. Department of the Navy, 2006). Another area of occurrence is seaward of 2,187 fathoms (4,000 m). Although sightings have been recorded around the mouth of Pearl Harbor, Hawaii, spinner dolphin occurrence is rare there (Lammers, 2004). Occurrence patterns are assumed to be the same throughout the year. Spinner dolphins were detected in nearshore waters off the western shore of Kauai during passive acoustic and visual surveys in 2014.

Open Ocean. Throughout much of their range, spinner dolphins are found in the open ocean. Spinner dolphins are pantropical, ranging through oceanic tropical and subtropical zones in both hemispheres (the range is nearly identical to that of the pantropical spotted dolphin). The primary range of Gray's spinner dolphin is known to include waters of the North Pacific Gyre and the southern waters of the North Pacific Transition Zone. Its range generally includes tropical and subtropical oceanic waters south of 40° N, continuous across the Pacific (Jefferson et al., 2015; Perrin and Gilpatrick, 1994).

Spinner dolphins are not considered a migratory species.

Population and Abundance

Hawaiian spinner dolphins belong to a separate stock than animals found in the eastern tropical Pacific. Abundance estimates are currently available for only three of the stocks composing the Hawaiian Islands Stock Complex: Hawaii Island – 790 individuals (CV = 0.17); Oahu and 4-Island – 355 individuals (CV = 0.09); and Kauai/Niihau – 601 individuals (CV = 0.20). Data are currently insufficient to calculate an abundance estimate for the remaining three stocks (Hawaii Pelagic, Midaway Atoll/Kure, and Pearl and Hermes Reef).

Predator/Prey Interactions

Spinner dolphins feed primarily on small mid-water fishes, squids, and shrimp, and they dive to at least 655 to 985 feet (200 to 300 m) (Perrin and Gilpatrick, 1994). They forage primarily at night, when the midwater community migrates toward the surface and the shore (Benoit-Bird, 2004; Benoit-Bird et al., 2001). Spinner dolphins track the horizontal migrations of their prey (Benoit-Bird and Au, 2003), allowing for foraging efficiencies (Benoit-Bird, 2004; Benoit-Bird and Au, 2003). Foraging behavior has also been linked to lunar phases in scattering layers off of Hawaii (Benoit-Bird and Au, 2004). Spinner dolphins may be preyed on by sharks, killer whales, pygmy killer whales, and short-finned pilot whales (Perrin, 2008c).

Species Specific Threats

There are no significant species-specific threats to spinner dolphins in the Study Area.

4.19 Rough-toothed Dolphin (*Steno bredanensis*)

Status and Management

This species is protected under the MMPA and is not listed under the ESA. Rough-toothed dolphins are among the most widely distributed species of tropical dolphins, but little information is available regarding population status (Jefferson, 2009b; Jefferson et al., 2015). Genetic studies and sighting data indicate there may be at least two island-associated stocks in the Main Hawaiian Islands (Hawaii Island and Kauai/Niihau stocks). However, at this time, NMFS has designated only a single Pacific management stock including animals found within the Hawaiian Islands EEZ (Carretta et al., 2010).

Geographic Range and Distribution

General. The range of this species is known to include waters of the Insular Pacific-Hawaiian Large Marine Ecosystems and the North Pacific Gyre. This species is known to prefer deep water but has been observed in waters of various depths. At the Society Islands, rough-toothed dolphins were sighted in waters with bottom depths ranging from less than 330 feet (100 m) to more than 9,845 feet (more than 3,000 m), although they apparently favored the 1,640 to 4,920 foot (500 to 1,500 m) range (Gannier, 2000).

Insular Pacific-Hawaiian Large Marine Ecosystem. The occurrence of this species is well known in deep ocean waters off Hawaii (Baird et al., 2008; Barlow et al., 2008; Carretta et al., 2010; Pitman and Stinchcomb, 2002; Shallenberger, 1981). Rough-toothed dolphin vocalizations have been detected during acoustic surveys in the eastern tropical Pacific (Oswald et al., 2003). A ship survey in the Hawaiian Islands found that sighting rates were highest in depths greater than 4,920 feet (1,500 m) and resightings were frequent, indicating the possibility of a small population with high site fidelity (Baird et al., 2008). This species has been observed as far northwest as French Frigate Shoals (Carretta et al., 2010). Eight strandings have been reported from the Hawaiian Islands of Maui, Oahu, and Hawaii (Maldini et al., 2005). Rough-toothed dolphins were detected in nearshore waters off the western shore of Kauai during passive acoustic and visual surveys in 2014.

Open Ocean. The rough-toothed dolphin is regarded as an offshore species that prefers deep water, but it can occur in waters of variable bottom depth (Gannier and West, 2005). It rarely occurs close to land, except around islands with steep drop-offs nearshore (Gannier and West, 2005). However, in some areas, this species may frequent coastal waters and areas with shallow bottom depths (Davis et al., 1998; Fulling et al., 2003; Lodi and Hetzel, 1999; Mignucci-Giannoni, 1998; Ritter, 2002).

There is no evidence that rough-toothed dolphins migrate. No information regarding routes, seasons, or resighting rates in specific areas is available.

Population and Abundance

Based on shipboard surveys of the Hawaiian Islands EEZ conducted in 2010 (Bradford et al., 2013), the best available abundance estimate for the Hawaii stock of rough-toothed dolphins is 6,288 individuals (CV = 0.39). Although island-specific stocks are not currently recognized by NMFS for management purposes, abundance estimates are provided in the most recent stock assessment report (Carretta et al., 2015) for Kauai/Niihau (1,665 individuals; CV = 0.33) and Hawaii Island (198 individuals; CV = 0.12). The island-specific estimates are based on photographic identification surveys conducted primarily within 40 km of shore, and are not considered representative of abundance within the Hawaiian Islands EEZ.

Predator/Prey Interactions

Prey of rough-toothed dolphins includes fish and cephalopods. They are known to feed on large fish species, such as mahi mahi (Miyazaki and Perrin, 1994; Pitman and Stinchcomb, 2002). They also prey on reef fish, as Perkins and Miller (1983) noted that parts of reef fish had been found in the stomachs of stranded rough-toothed dolphins in Hawaii. Gannier and West (2005) observed rough-toothed dolphins feeding during the day on near-surface fishes, including flying fishes.

Although this species has not been documented as prey by other species, it may be subject to predation from killer whales.

Species Specific Threats

Rough-toothed dolphins are particularly susceptible to commercial and recreational fishery interactions.

4.20 Fraser's Dolphin (*Lagenodelphis hosei*)

Although information on Fraser's dolphin has increased in recent years, the species is still one of the least-known cetaceans. Fraser's dolphin was discovered in 1956, and after that time was known only from skeletal remains until it was once again identified in the early 1970s (Perrin et al., 1973).

Status and Management

Fraser's dolphin is protected under the MMPA and is not listed under the ESA. For the MMPA stock assessment reports, there is a single Pacific management stock that includes only animals found within the Hawaiian Islands EEZ.

Geographic Range and Distribution

General. Fraser's dolphin is a tropical oceanic species, except where deep water approaches the coast (Dolar, 2008).

Insular Pacific-Hawaiian Large Marine Ecosystem. Fraser's dolphins have only recently been documented within the Insular Pacific-Hawaiian Large Marine Ecosystem. The first published sightings were during a 2002 cetacean survey (Barlow, 2006; Carretta et al., 2010), at which time the mean group size recorded was 286 (Barlow, 2006). An additional sighting was recorded off the Island of Hawaii in 2008. There are no records of strandings of this species in the Hawaiian Islands (Maldini et al., 2005). Fraser's dolphin vocalizations have been documented in the Hawaiian Islands (Barlow et al., 2008; Barlow et al., 2004). It is not known whether Fraser's dolphins found in Hawaiian waters are part of the same population that occurs in the eastern tropical Pacific (Carretta et al., 2010).

Open Ocean. In the offshore eastern tropical Pacific, this species is distributed mainly in upwelling-modified waters (Au and Perryman, 1985; Reilly, 1990). The range of this species includes deep open ocean waters of the North Pacific Gyre and the Insular Pacific-Hawaiian Large Marine Ecosystem and other locations in the Pacific (Aguayo and Sanchez, 1987; Ferguson, 2005; Miyazaki and Wada, 1978).

This does not appear to be a migratory species, and little is known about its potential migrations. No specific information regarding routes, seasons, or resighting rates in specific areas is available.

Population and Abundance

The current best available abundance estimate for the Hawaii stock of Fraser's dolphin derives from a 2002 shipboard survey of the entire Hawaiian Islands EEZ, resulting in an estimate of 16,992 (CV = 0.66) (Bradford et al., 2013).

Predator/Prey Interactions

Fraser's dolphin feeds on mid-water fishes, squids, and shrimps and has not been documented to be prey to any other species (Jefferson and Leatherwood, 1994; Perrin et al., 1994b). It may, however, be subject to predation by killer whales.

Species Specific Threats

There are no significant species-specific threats to Fraser's dolphins in the Study Area.

4.21 Risso's Dolphin (*Grampus griseus*)

Status and Management

Risso's dolphin is protected under the MMPA and is not listed under the ESA. For the MMPA stock assessment reports, Risso's dolphins within the Pacific U.S. EEZ are divided into two separate areas: waters off California, Oregon, and Washington; and Hawaiian waters (Carretta et al., 2010).

Geographic Range and Distribution

General. In the Pacific, the range of this species is known to include the North Pacific Gyre and the California Current and Insular Pacific-Hawaiian Large Marine Ecosystems. Occurrence of this species is well known in deep open ocean waters off Hawaii, and in other locations in the Pacific (Au and Perryman, 1985; Carretta et al., 2010; Leatherwood et al., 1980; Miyashita, 1993; Miyashita et al., 1996; Wang et al., 2001).

Insular Pacific-Hawaiian Large Marine Ecosystem. Risso's dolphins have been considered rare in Hawaiian waters (Shallenberger, 1981). However, during a 2002 survey of the Hawaiian Islands EEZ, seven sightings were reported; in addition, two sightings were reported from recent aerial surveys in the Hawaiian Islands (Barlow, 2006; Mobley et al., 2000). During a more recent 2010 systematic survey of the Hawaiian Islands EEZ, there were 12 sightings of Risso's dolphins. In 2009, Risso's dolphins were acoustically detected near Hawaii using boat-based hydrophones (U.S. Department of the Navy, 2009a). In addition, Risso's dolphins were sighted eight times during Navy monitoring activities within HRC between 2005 and 2012 (HDR, 2012). Five stranding records exist from the Main Hawaiian Islands (Maldini et al., 2005).

Open Ocean. Several studies have documented that Risso's dolphins are found offshore, along the continental slope, and over the outer continental shelf (Baumgartner, 1997; Canadas et al., 2002; Cetacean and Turtle Assessment Program, 1982; Davis et al., 1998; Green et al., 1992; Kruse et al., 1999; Mignucci-Giannoni, 1998). Risso's dolphins are also found over submarine canyons (Mussi et al., 2004).

Risso's dolphin does not migrate, although schools may range over very large distances. Seasonal shifts in centers of abundance are known for some regions.

Population and Abundance

This is a widely distributed species that occurs in all major oceans, and although no global population estimates exist, it is generally considered to be one of the most abundant of the large dolphins. The current best available abundance estimate for the Hawaiian stock of Risso's dolphin derives from a 2010 shipboard survey of the entire Hawaiian Islands EEZ (Bradford et al., 2013). The resulting abundance estimate is 7,526 individuals (CV = 0.41).

Predator/Prey Interactions

Cephalopods and crustaceans are the primary prey for Risso's dolphins (Clarke, 1996), which feed mainly at night (Baird et al., 2008; Jefferson et al., 2015). This dolphin may be preyed on by both killer whales and sharks, although there are no documented reports of predation by either species (Weller, 2008).

Species Specific Threats

Risso's dolphins are particularly susceptible to entanglement and fisheries interactions.

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

Status and Management

Cuvier's beaked whale is protected under the MMPA and is not listed under the ESA. Cuvier's beaked whale stocks are defined for three separate areas within Pacific U.S. waters: (1) Alaska, (2) California, Oregon, and Washington, and (3) Hawaii.

Geographic Range and Distribution

General. Cuvier's beaked whales have an extensive range that includes all oceans, from the tropics to the polar waters of both hemispheres. Worldwide, beaked whales normally inhabit continental slope and deep oceanic waters. Cuvier's beaked whales are generally sighted in waters with a bottom depth greater than 655 feet (199.6 m) and are frequently recorded in waters with bottom depths greater than 3,280 feet (999.7 m) (Falcone et al., 2009; Jefferson et al., 2015). Cuvier's beaked whale range is known to include all waters of the Insular Pacific-Hawaiian Large Marine Ecosystems, the North Pacific Gyre, and the North Pacific Transition Zone (Jefferson et al., 2015; MacLeod and D'Amico, 2006).

Insular Pacific-Hawaiian Large Marine Ecosystem. Cuvier's beaked whales are regularly found in waters surrounding the Hawaiian Islands, having been sighted from vessels and aerial surveys. A line-transect survey conducted in February 2009 by the Cetacean Research Program surrounding the Hawaiian Islands (Oleson and Hill, 2009) resulted in the sighting of 2 Cuvier's beaked whales, while shipboard surveys of the Hawaiian Islands EEZ in 2020 (Bradford et al., 2013) resulted in 22 sightings. They typically are found at depths exceeding 6,560 feet (2,000 m) (Baird et al., 2009b; Baird et al., 2006b; Barlow et al., 2004). In the Hawaiian Islands, five strandings have been reported from Midway Island, Pearl and Hermes Reef, Oahu, and the Island of Hawaii (Maldini et al., 2005; Shallenberger, 1981). Sightings have been reported off the Hawaiian Islands of Lanai, Maui, Hawaii, Niihau, and Kauai, supporting the hypothesis that there is a resident population found in the Hawaiian Islands (Baird et al., 2010a; Carretta et al., 2010; Mobley et al., 2000; Shallenberger, 1981).

Open Ocean. Cuvier's beaked whales are widely distributed in offshore waters of all oceans and thus occur in temperate and tropical waters of the Pacific, including waters of the eastern tropical Pacific (Barlow et al., 2006; Ferguson, 2005; Jefferson et al., 2015; Pitman et al., 1988). In the Study Area, they are found mostly offshore in deeper waters off Hawaii (MacLeod and Mitchell, 2006; Mead, 1989; Ohizumi and Kishiro, 2003; Wang et al., 2001). A single population likely exists in offshore waters of the eastern north Pacific, ranging from Alaska south to Mexico (Carretta et al., 2010). Little is known about potential migration.

Population and Abundance

The current best available abundance estimate for the Hawaii stock is 1,941 individuals (CV = 0.70), based on a 2010 shipboard line-transect survey of the Hawaiian Islands EEZ (Bradford et al., 2013).

Predator/Prey Interactions

Cuvier's beaked whales, similar to other beaked whale species, are apparently deepwater feeders. Stomach content analyses show that they feed mostly on deep-sea squid, fish, and crustaceans (Hickmott, 2005; Santos et al., 2007). They apparently use suction to swallow prey (Jefferson et al., 2015; Werth, 2006a; Werth, 2006b). Cuvier's beaked whales may be preyed upon by killer whales (Heyning and Mead, 2008; Jefferson et al., 2015).

Species Specific Threats

Cuvier's beaked whales commonly strand, and they are considered vulnerable to acoustic impacts (Frantzis et al., 2002; Cox et al., 2006; Southall et al., 2012). Additionally, Cuvier's beaked whales have been documented being entangled in fishing gear.

4.23 Blainville's Beaked Whale (*Mesoplodon densirostris*)

Status and Management

Due to difficulty in distinguishing the different *Mesoplodon* species from one another, the U.S. management unit is usually defined to include all *Mesoplodon* species that occur in an area. Blainville's beaked whale is protected under the MMPA and is not listed under the ESA. Although little is known of stock structure for this species, based on resightings and genetic analysis of individuals around the Hawaiian Islands, NMFS recognizes a Hawaii stock of Blainville's beaked whale.

Geographic Range and Distribution

General. Blainville's beaked whales are one of the most widely distributed of the distinctive toothed whales within the *Mesoplodon* genus (Jefferson et al., 2015; MacLeod and Mitchell, 2006). Blainville's beaked whale range is known to include the Insular Pacific-Hawaiian Large Marine Ecosystems, North Pacific Gyre, and the North Pacific Transition Zone (Jefferson et al., 2015; Pitman, 2008a).

Insular Pacific-Hawaiian Large Marine Ecosystem. Blainville's beaked whales are regularly found in Hawaiian waters (Baird et al., 2003a; Baird et al., 2006b; Barlow et al., 2004). In Hawaiian waters, this species is typically found in areas where water depths exceed 3,280 feet (1,000 m) along the continental slope (Barlow et al., 2006; Baird et al., 2010a). Blainville's beaked whale has been detected off the coast of Oahu, Hawaii, for prolonged periods annually, and this species is consistently observed in the same site off the west coast of the island of Hawaii (McSweeney et al., 2007). Blainville's beaked whales' vocalizations have been detected on acoustic surveys in the Hawaiian Islands, and stranding records are available for the region (Maldini et al., 2005; Rankin and Barlow, 2007). A recent tagging study off the island of Hawaii found the movements of a Blainville's beaked whale to be restricted to the waters of the west and north side of the island (Baird et al., 2010a). Blainville's beaked whales were detected in nearshore waters off the western shore of Kauai during passive acoustic and visual surveys in 2014.

Open Ocean. Blainville's beaked whales are found mostly offshore in deeper waters along the California coast, Hawaii, Fiji, Japan, and Taiwan, as well as throughout the eastern tropical Pacific (Leslie et al., 2005; MacLeod and Mitchell, 2006; Mead, 1989). It is unknown whether this species makes specific migrations, and none have so far been documented. Populations studied in Hawaii have evidenced some level of residency (McSweeney et al., 2007).

Population and Abundance

The best available abundance estimate for Blainville's beaked whale Hawaii stock is based on a 2010 shipboard line-transect survey of the entire Hawaiian Islands EEZ (Bradford et al., 2013). The resulting estimate is 2,338 individuals (CV = 1.13).

Predator/Prey Interactions

This species preys on squid and possibly deepwater fish. Like other *Mesoplodon* species, Blainville's beaked whales apparently use suction for feeding (Jefferson et al., 2015; Werth, 2006a; Werth, 2006b). This species has not been documented to be prey to any other species although, like other cetaceans, it is likely subject to occasional killer whale predation.

Species Specific Threats

Blainville's beaked whales have been shown to react to anthropogenic noise by avoidance (Tyack et al., 2011). In response to a simulated sonar signal and pseudorandom noise (a signal of pulsed sounds that are generated in a random pattern), a tagged whale ceased foraging at depth and slowly moved away from the source while gradually ascending toward the surface (Tyack et al., 2011).

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

Status and Management

Longman's beaked whale is protected under the MMPA and is not listed under the ESA. Longman's beaked whale is a rare beaked whale species and is considered one of the world's least-known cetaceans (Dalebout et al., 2003; Pitman, 2008a). Only one Pacific stock, the Hawaii stock, is identified (Carretta et al., 2010).

Geographic Range and Distribution

General. Longman's beaked whales generally are found in warm tropical waters, with most sightings occurring in waters with sea surface temperatures warmer than 78° Fahrenheit (26° Celsius) (Anderson et al., 2006; MacLeod and D'Amico, 2006; MacLeod et al., 2006a). Sighting records of this species in the Indian Ocean showed Longman's beaked whale typically found over deep slopes 655 to 6,560 (or more) feet (200 to 2,000 [or more] m) (Anderson et al., 2006).

Although the full extent of this species distribution is not fully understood, there have been many recorded sightings at various locations in tropical waters of the Pacific and Indian Oceans (Afsal et al., 2009; Dalebout et al., 2002; Dalebout et al., 2003; Moore, 1972). Ferguson et al. (2001) reported that all Longman's beaked whale sightings were south of 25° N.

Records of this species indicate presence in the eastern, central, and western Pacific. The range of Longman's beaked whale generally includes the Insular Pacific-Hawaiian Large Marine Ecosystems and the North Pacific Gyre (Gallo-Reynoso and Figueroa-Carranza, 1995; Jefferson et al., 2015; MacLeod and D'Amico, 2006).

Insular Pacific-Hawaiian Large Marine Ecosystem. Sighting records for this species indicate presence in waters to the west of the Hawaiian Islands (four Longman's beaked whales were observed during the 2002 Hawaiian Islands Cetacean and Ecosystem Assessment also known as the HICEAS survey, Barlow et al., 2004) and to the northwest of the Hawaiian archipelago (23°42'38" N and 176°33'78" W). During a more recent 2010 HICEAS survey, there were multiple sightings of Longman's beaked whale. Longman's beaked whales have also been sighted off Kona (Cascadia Research, 2012b). Shipboard surveys of the Hawaiian Islands EEZ in 2010 resulted in three sightings (Bradford et al., 2013). Two known records exist of this species stranding in the Hawaiian Islands (Maldini et al., 2005; West et al., 2012).

Open Ocean. Worldwide, Longman's beaked whales normally inhabit continental slope and deep oceanic waters (greater than 655 feet [200 m]), and are only occasionally reported in waters over the continental shelf (Canadas et al., 2002; Ferguson et al., 2006; MacLeod et al., 2006a; Pitman, 2008a; Waring et al., 2001).

Little information regarding the migration of this species is available, but it is considered to be widely distributed across the tropical Pacific and Indian Oceans (Jefferson et al., 2015). It is unknown whether the Longman's beaked whale participates in a seasonal migration (Jefferson et al., 2015; Pitman, 2008a).

Population and Abundance

Based on 2010 surveys of the Hawaiian Islands EEZ (Bradford et al., 2013), the best available abundance estimate of the Hawaii stock is 4,571 individuals (CV = 0.65).

Predator/Prey Interactions

Based on recent tagging data from Cuvier's and Blainville's beaked whales, Baird et al. (2005b) suggested that feeding for Longman's beaked whale might occur at mid-water rather than only at or near the bottom (Heyning, 1989; MacLeod et al., 2003). This species has not been documented to be prey to any other species, though it is likely subject to occasional killer whale predation.

Species Specific Threats

Little information exists regarding species-specific threats to Longman's beaked whales in the Study Area. However, recently the first case of morbillivirus in the central Pacific was documented for a stranded juvenile male Longman's beaked whale at Hamoa beach, Hana, Maui (West et al., 2012).

4.25 Hawaiian Monk Seal (*Neomonachus schauinslandi*)

Status and Management

The Hawaiian monk seal was listed as endangered under the ESA in 1976, and is listed as depleted under the MMPA. The species is considered a high priority for recovery, based on the high magnitude of threats, the high recovery potential, and the potential for economic conflicts while implementing recovery actions (NMFS, 2007d). Hawaiian monk seals are managed as a single stock. NMFS has identified reproductive subpopulations at French Frigate Shoals, Laysan Island, Lisianski Island, Pearl and Hermes Reef, Midway Atoll, Kure Atoll, and Necker and Nihoa Islands in the Northwestern Hawaiian Islands (NMFS, 2014). The species also occurs throughout the Main Hawaiian Islands (e.g., there is a population of approximately 200 individuals in the Main Hawaiian Islands [NMFS, 2016] and the total population is estimated to be fewer than 1,200 individuals). The approximate area encompassed by the Northwestern Hawaiian Islands was designated as the Papahānaumokuākea Marine National Monument in 2006.

A recovery plan for the Hawaiian monk seal was completed in 1983 and was revised in 2007 (NMFS, 2007d). In 1986, critical habitat was designated for all beach areas, sand spits and islets, lagoon waters, inner reef waters, and ocean waters to a depth of 10 fathoms (18.3 m) around Kure Atoll, Midway Islands (except Sand Island), Pearl and Hermes Reef, Lisianski Island, Laysan Island, Gardner Pinnacles, French Frigate Shoals, Necker Island, and Nihoa Island in the Northwestern Hawaiian Islands (NMFS, 1986). In 1988, the critical habitat was extended to include Maro Reef and waters around previously recommended areas out to the 20 fathom (36.6 m) isobath (NMFS, 1988). In order to reduce the probability of direct interaction between Hawaiian-based long-line fisheries and monk seals, a Protected Species Zone was put into place in the Northwestern Hawaiian Islands, prohibiting long-line fishing in this zone. In 2000, the waters from 3 to 50 NM around the Northwestern Hawaiian Islands were designated as the Northwestern Hawaiian Islands Coral Reef Ecosystem Reserve, and specific restrictions were placed on human activities there (Antonelis et al., 2006).

In 2008, NMFS received a petition requesting that the critical habitat in the Northwestern Hawaiian Islands be expanded to include Sand Island at Midway and ocean waters out to a depth of 500 m and that the following critical habitat be added in the Main Hawaiian Islands: key beach areas, sand spits and islets, lagoon waters, inner reef waters, and ocean waters to a depth of 200 m. In 2009, NMFS announced a 12-month finding indicating the intention to revise critical habitat, and in 2011 NMFS proposed that critical habitat in the Northwestern Hawaiian Islands be expanded to include Sand Island at Midway and ocean waters out to a depth of 500 m and that six new extensive areas in the Main Hawaiian Islands be added. In August 2015, NMFS published a final rule revising critical habitat designation to include 10 areas in the Northwestern Hawaiian Islands and 6 areas in the Main Hawaiian Islands (50 CFR Part 226, 21 August 2015). NMFS excluded several areas from designation because either (1) the national security benefits of exclusion outweigh the benefits of inclusion (and exclusion will not result in extinction of the species), or (2) they are managed under Integrated Natural Resource Management Plans that provide a benefit to the species (these areas are termed “ineligible” for critical habitat designation). Critical Habitat Specific Area 13 includes portions of the Kauai coastline and associated marine waters. However, portions of the PMRF were excluded, including the PMRF Main Base at Barking Sands and the PMRF Offshore Areas in marine areas off the western coast of Kauai. Hawaiian monk seal critical habitat is shown in Figure 4-2.

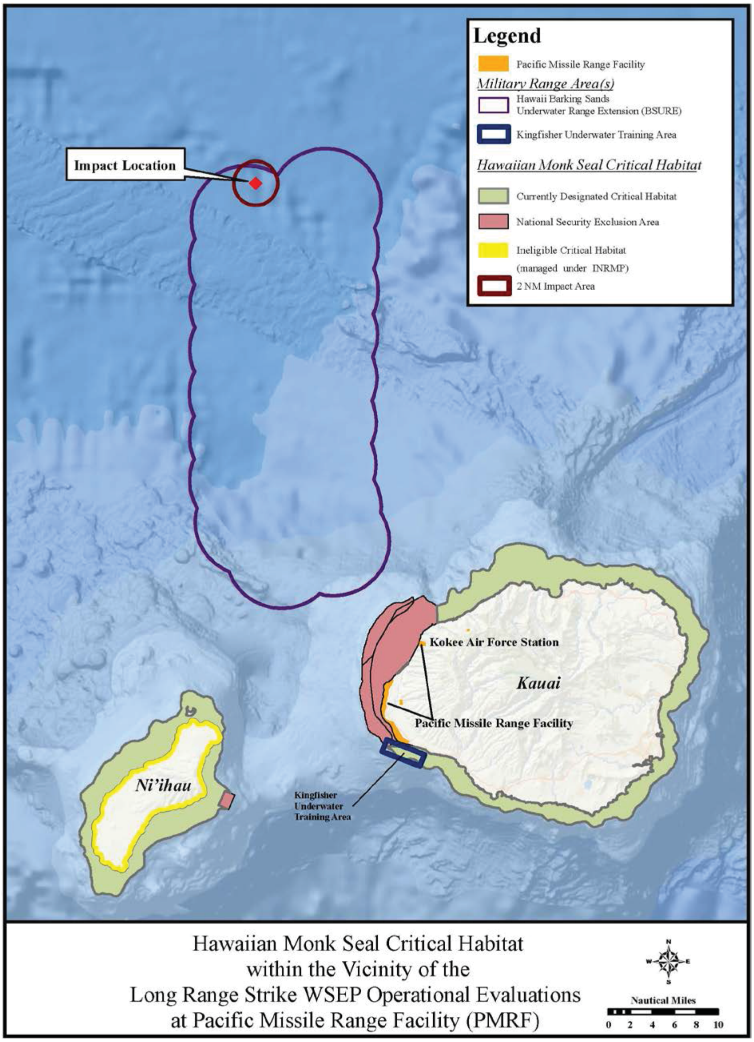
The Pacific Island Regional Office of NMFS has the lead responsibility for the recovery of Hawaiian monk seals under the ESA and the MMPA. Since the early 1980s, NMFS has routinely applied flipper tags to weaned pups in the Northwestern Hawaiian Islands (Antonelis et al., 2006). NMFS performed capture and release programs through the Head Start Program between 1981 and 1991, “to enhance the survival of young females and thereby increase their subsequent recruitment into the adult female population.” From 1984 to 1995, under NMFS’s Rehabilitation Project, undersized, weaned female pups from French Frigate Shoals and, in some cases, undersized juvenile females, were brought into captivity for 8 to 10 months on Oahu to increase their weight. They were then released into the wild at either Kure Atoll or Midway Islands, where they had a higher probability of survival (Antonelis et al., 2006). Because some males were injuring female seals, in July and August of 1994, 21 adult male Hawaiian monk seals were relocated from Laysan Island to the Main Hawaiian Islands (NMFS, 2009a). NMFS has relocated three female monk seals (a juvenile in 1981, a pup in 1991, and an adult in 2009) from the Main Hawaiian Islands to the Northwestern Hawaiian Islands (NMFS, 2009a).

Other agencies that also play an important role in the Northwestern Hawaiian Islands are the Marine Mammal Commission, the USFWS, which manages wildlife habitat and human activities within the lands and waters of the Hawaiian Islands National Wildlife Refuge and the Midway Atoll National Wildlife Refuge; the U.S. Coast Guard, which assists with enforcement and efforts to clean up marine pollution; the National Ocean Service, which conserves natural resources in the Northwestern Hawaiian Islands Coral Reef Ecosystem Reserve; and the Western Pacific Regional Fishery Management Council, which develops fishery management plans and proposes regulations to NMFS for commercial fisheries around the Northwestern Hawaiian Islands (Marine Mammal Commission, 2002).

The State of Hawaii also has important responsibilities for monk seal conservation and recovery. It owns Kure Atoll and has jurisdiction over waters between the reserve boundary and 3 NM around all emergent lands in the Northwestern Hawaiian Islands (except Midway) (Marine Mammal Commission, 2002). In March 2007, the State of Hawaii put new regulations into place to restrict the use of lay nets on Oahu, Molokai, Lanai, Kauai, and Niihau and prohibited lay net use in state waters around the entire island of Maui and certain areas on Oahu (NMFS, 2010c). In 2008, in hopes of raising awareness of the species, Hawaii’s Lieutenant Governor signed into law legislation that established the Hawaiian monk seal as the official state mammal.

When seals are reported on beaches in the main islands, NMFS works with state and local agencies to cordon off sections of beach around the seals. NMFS also relies on volunteer groups to observe seals and educate the public about their endangered status and protection measures. On Oahu, the Hawaiian Monk Seal Response Team Oahu is a team of over 50 volunteers who routinely assist NOAA Fisheries Pacific Island Regional Office and the Pacific Island Fisheries Science Center in monk seal response issues. Monk seal response programs also exist on Kauai, Maui, and the Island of Hawaii, with some reporting from Molokai and Lanai (NMFS, 2010c).

Figure 4-2. Critical Habitat of the Hawaiian Monk Seal near the Study Area



There is also a multiagency marine debris working group that was established in 1998 to remove derelict fishing gear, which has been identified as a top threat to this species, from the Northwestern Hawaiian Islands (Donohue and Foley, 2007). Agencies involved in these efforts include The Ocean Conservancy, the City and County of Honolulu, the Coast Guard, the USFWS, the Hawaii Wildlife Fund, the Hawaii Sea Grant Program, the National Fish and Wildlife Foundation, the Navy, the University of Alaska Marine Advisory Program, and numerous other state and private agencies and groups (Marine Mammal Commission, 2002).

The Navy has previously funded some monk seal tagging projects conducted by Pacific Islands Fisheries Science Center personnel. In addition, since 2013, some collaborative projects have been undertaken under the PMRF Integrated Natural Resources Management Plan.

Geographic Range and Distribution

General. Monk seals can rapidly cover large areas in search of food and may travel hundreds of miles in a few days (Littnan et al., 2007).

Insular Pacific-Hawaiian Large Marine Ecosystem. The Hawaiian monk seal is the only endangered marine mammal whose range is entirely within the United States (NMFS, 2007d). Hawaiian monk seals can be found throughout the Hawaiian Island chain in the Insular Pacific-Hawaiian Large Marine Ecosystem. Sightings have also occasionally been reported on nearby island groups south of the Hawaiian Island chain, such as Johnston Atoll, Wake Island, and Palmyra Atoll (Carretta et al., 2010; Gilmartin and Forcada, 2009; Jefferson et al., 2015; NMFS, 2009a). The main breeding sites are in the Northwestern Hawaiian Islands: French Frigate Shoals, Laysan Island, Lisianski Island, Pearl and Hermes Reef, Midway Atoll, Kure Atoll, and Necker and Nihoa Islands. Monk seals have also been observed at Gardner Pinnacles and Maro Reef. A small breeding population of monk seals is found throughout the Main Hawaiian Islands, where births have been documented on most of the major islands, especially Kauai (Gilmartin and Forcada, 2009; NMFS, 2007d; NMFS, 2010b). It is possible that, before Western contact, Polynesians drove many Hawaiian monk seals from the Main Hawaiian Islands to less desirable habitat in the Northwestern Hawaiian Islands (Baker and Johanos, 2004).

Although the Hawaiian monk seal is found primarily on the Northwestern Hawaiian Islands (NMFS, 2014), sightings on the Main Hawaiian Islands have become more common (Johanos et al., 2015). During Navy-funded marine mammal surveys from 2007 to 2012, there were 41 sightings of Hawaiian monk seals, with a total of 58 individuals on or near Kauai, Kaula, Niihau, Oahu, and Molokai (HDR, 2012). Forty-seven (81 percent) individuals were seen during aerial surveys, and 11 (19 percent) during vessel surveys. Monk seals were most frequently observed at Niihau.

Monk seals are generally thought to spend most of their time at sea in nearshore, shallow marine habitats (Littnan et al., 2007). However, recent research suggests that the seals may use the open ocean more extensively than previously thought (see the *Predator/Prey Interactions* subsection below). When hauled out, Hawaiian monk seals seem to prefer beaches of sand, coral rubble, and rocky terraces (Baker et al., 2006; Jefferson et al., 2015).

Climate models predict that global average sea levels may rise this century, potentially affecting species that rely on the coastal habitat. Topographic models of the low-lying Northwestern Hawaiian Islands were created to evaluate potential effects of sea level rise by 2100. Monk seals, which require the islands for resting, molting, and nursing, may experience more crowding and competition if islands shrink (Baker et al., 2006).

Based on one study, on average, 10 to 15 percent of the monk seals migrate among the Northwestern Hawaiian Islands and the Main Hawaiian Islands (Carretta et al., 2010). Another source suggests that about 36 percent of the main Hawaiian Island seals travel between islands throughout the year (Littnan, 2011).

Population and Abundance

Currently, the best estimate for the total population of monk seals is 1,153 (Carretta et al., 2015). Population dynamics at the different locations in the Northwestern Hawaiian Islands and the Main Hawaiian Islands has varied considerably (Antonelis et al., 2006). A population model for 2003 through 2012 suggests a decline in overall population of about 3.3 percent. However, the Main Hawaiian Islands population appears to be increasing, possibly at a rate of about 7 percent per year (NMFS, 2014). In the Main Hawaiian Islands, a minimum abundance of 45 seals was found in 2000, and this increased to 52 in 2001 (Baker, 2004). In 2009, 113 individual seals were identified in the Main Hawaiian Islands based on flipper tag ID numbers or unique natural markings. The total number in the Main Hawaiian Islands is currently estimated to be about 200 animals (NMFS, 2016). Beach counts in the Northwestern Hawaiian Islands since the late 1950s have shown varied population trends at specific times, but in general, abundance is low at most islands (NMFS, 2014).

Possible links between the spatial distribution of primary productivity in the Northwestern Hawaiian Islands and trends of Hawaiian monk seal abundance have been assessed for the past 40 years. Results demonstrate that monk seal abundance trends appear to be affected by the quality of local environmental conditions (including sea surface temperature, vertical water column structure, and integrated chlorophyll) (Schmelzer, 2000). Limited prey availability may be restricting the recovery of the Northwestern Hawaiian Islands monk seals (Baker, 2008; Brillinger et al., 2006; Carretta et al., 2010). Studies performed on pup survival rate in the Northwestern Hawaiian Islands between 1995 and 2004 showed severe fluctuations between 40 percent and 80 percent survival in the first year of life. Survival rates between 2004 and 2008 showed an increase at Lisianski Island and Pearl, Hermes, Midway, and Kure Atoll and a decrease at French Frigate Shoals and Laysan Island. Larger females have a higher survival rate than males and smaller females (Baker, 2008).

Estimated chances of survival from weaning to age one are higher in the Main Hawaiian Islands (77 percent) than in the Northwestern Hawaiian Islands (42 to 57 percent) (Littnan, 2011). The estimated Main Hawaiian Islands intrinsic rate of population growth is greater as well. If current trends continue, abundances in the Main Hawaiian Islands could eventually exceed that of the Northwestern Hawaiian Islands (NMFS, 2014). There are a number of possible reasons why pups in the Main Hawaiian Islands are faring better. One is that the per capita availability of prey may be higher in the Main Hawaiian Islands, due to the low monk seal population (Baker and Johanos, 2004). Another may have to do with the structure of the marine communities. In the Main Hawaiian Islands, the seals have less competition with other top predators, like large sharks, jacks, and other fish, which may enhance their foraging success (Baker and Johanos, 2004; Parrish et al., 2008).

A third factor may be the limited amount of suitable foraging habitat in the Northwestern Hawaiian Islands (Stewart et al., 2006). While foraging conditions are better in the Main Hawaiian Islands than in the Northwestern Hawaiian Islands, health hazards from exposure to pollutants and infectious disease agents associated with terrestrial animals pose risks not found in the Northwestern Hawaiian Islands (Littnan et al., 2007). Despite these risks, a self-sustaining subpopulation in the Main Hawaiian Islands could improve the monk seal's long-term prospects for recovery (Baker and Johanos, 2004; Carretta et al., 2005; Marine Mammal Commission, 2003).

Predator/Prey Interactions

The Hawaiian monk seal is a foraging generalist, often moving rocks to capture prey underneath (NMFS, 2014). Monk seals feed on many species of fish, cephalopods, and crustaceans. Prey species include representatives of at least 31 bony fish families, 13 cephalopod (octopus, squid, and related species) families, and numerous crustaceans (e.g., crab and lobster). Foraging typically occurs on the seafloor from the shallows to water depths of over 500 m. Data from tagged individuals indicate foraging occurs primarily in areas of high bathymetric relief within 40 km (25 miles) of atolls or islands, although submerged banks and reefs located over 300 km from breeding sites may also be used (NMFS, 2014). In general, seals associated with the Main Hawaiian Islands appear to have smaller home ranges, travel shorter distances to feed, and spend less time foraging than seals associated with the Northwestern Hawaiian Islands. The inner reef waters next to the islands are critical to weaned pups learning to feed; pups move laterally along the shoreline, but do not appear to travel far from shore during the first few months after weaning (Gilmartin and Forcada, 2009). Feeding has been observed in reef caves, as well as on fish hiding among coral formations (Parrish et al., 2000). A recent study showed that this species is often accompanied by large predatory fish, such as jacks, sharks, and snappers, which possibly steal or compete for prey that the monk seals flush with their probing, digging and rock-flipping behavior. The juvenile monk seals may not be of sufficient size or weight to get prey back once it has been stolen. This was noted only in the French Frigate Shoals (Parrish et al., 2008).

Monk seals and are known to be preyed on by both killer whales and sharks. Shark predation is one of the major sources of mortality for this species especially in the Northwestern Hawaiian Islands. Galapagos sharks are a large source of juvenile mortality in the Northwestern Hawaiian Islands, with most predation occurring in the French Frigate Shoals (Antonelis et al., 2006; Gilmartin and Forcada, 2009; Jefferson et al., 2015).

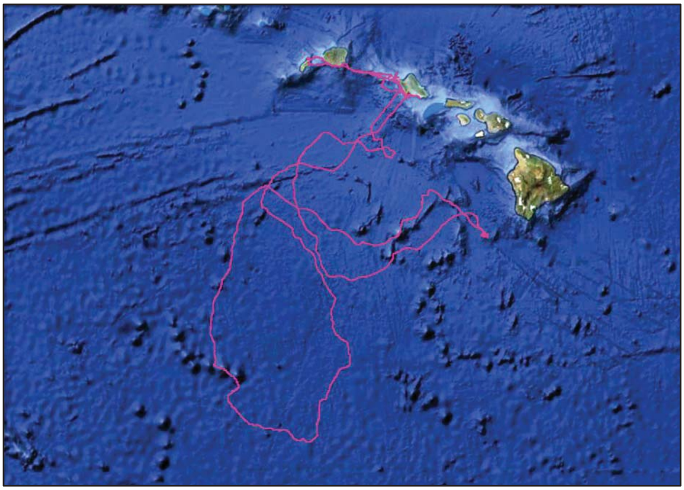
In an effort to better understand the habitat needs of foraging monk seals, (Stewart et al., 2006) used satellite-linked radio transmitters to document the geographic and vertical foraging patterns of 147 Hawaiian monk seals from all six Northwestern Hawaiian Islands breeding colonies, from 1996 through 2002. Geographic patterns of foraging were complex and varied among colonies by season, age, and sex, but some general patterns were evident. Seals were found to forage extensively within barrier reefs of the atolls and on the leeward slopes of reefs and islands at all colony sites. They also ranged away from these sites along the Hawaiian Islands submarine ridge to most nearby seamounts and submerged reefs and banks (Stewart et al., 2006).

In 2005, 11 juvenile and adult monk seals were tracked in the Main Hawaiian Islands using satellite-linked radio transmitters showing location, but not depth (Littnan et al., 2007). Similar to the Northwestern Hawaiian Islands, monk seals showed a high degree of individual variability. Overall results showed most foraging trips to last from a few days to two weeks, with seals remaining within the 200 m isobaths surrounding the Main Hawaiian Islands and nearby banks (Littnan et al., 2007).

NMFS and the Navy have also monitored monk seals with cell phone tags (Littnan, 2011; Reuland, 2010). Results from one individual monk seal (R012) indicated travel of much greater distances and water depths than previously documented (Littnan, 2011). The track of this monk seal extended as much as 470 miles (756.4 km) from shore and a total distance of approximately 2,000 miles (3,218.7 km) where the ocean depth is over 5,000 meters (16,404 feet) (Figure 4-3). However, the distance traveled by this individual was substantially greater than that of foraging trips undertaken by other seals in the study and may not represent typical behavior (Littnan, 2012).

Figure 4-3. Track of Hawaiian Monk Seal R012 in June 2010

Source: NOAA Fisheries, 2015



Species Specific Threats

Monk seals are particularly susceptible to fishery interactions and entanglements. In the Northwestern Hawaiian Islands, derelict fishing gear has been identified as a top threat to the monk seal (Donohue and Foley, 2007), while in the Main Hawaiian Islands, high risks are associated with health hazards from exposure to pollutants and infectious disease agents associated with terrestrial animals. Limited prey availability may be restricting the recovery of the Northwestern Hawaiian Islands monk seals (Baker, 2008; Brillinger et al., 2006; Carretta et al., 2010). Since they rely on coastal habitats for survival, monk seals may be affected by future sea level rise and loss of habitat as predicted by global climate models. Another species-specific threat includes aggressive male monk seals that have been documented to injure and sometimes kill females and pups (NMFS, 2010c). Other threats include reduced prey availability, shark predation, disease and parasites, and contaminants (NMFS, 2014).

This page is intentionally blank.

5.0 TAKE AUTHORIZATION REQUESTED

The MMPA established, with limited exceptions, a moratorium on the “taking” of marine mammals in waters under U.S. jurisdiction. The act further regulates “takes” of marine mammals in the high seas by vessels or persons under U.S. jurisdiction. The term *take*, as defined in Section 3 (16 United States Code [USC] 1362) of the MMPA, means “to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal.” *Harassment* was further defined in the 1994 amendments to the MMPA, which provided for two levels: Level A (potential injury) and Level B (potential disturbance).

The National Defense Authorization Act of fiscal year 2004 (Public Law 108-136) amended the definition of harassment for military readiness activities. Military readiness activities, as defined in Public Law 107-314, Section 315(f), includes all training and operations related to combat, and the adequate and realistic testing of military equipment, vehicles, weapons, and sensors for proper operation and suitability for combat. This definition, therefore, includes air-to-surface test activities occurring in the BSURE. The amended definition of harassment for military readiness activities is any act that:

- Injures or has the significant potential to injure a marine mammal or marine mammal stock in the wild (“Level A harassment”), or
- Disturbs or is likely to disturb a marine mammal or marine mammal stock in the wild by causing disruption of natural behavioral patterns including but not limited to migration, surfacing, nursing, breeding, feeding, or sheltering to a point where such behavioral patterns are abandoned or significantly altered (“Level B harassment”) (16 USC 1362 [18][B][i],[ii]).

Section 101(a)(5) of 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 (exclusive of commercial fishing) within a specified geographic region. These incidental takes may be allowed if NMFS determines the taking will have a negligible impact on the species or stock and the taking will not have an unmitigable adverse impact on the availability of such species or stock for taking for subsistence uses.

Pursuant to Section 101(a)(5), an IHA for the incidental taking (but not intentional taking) of marine mammals is requested for Long Range Strike WSEP mission activities within the BSURE area, as described in Section 1, *Description of Activities*. The results of acoustic modeling for surface detonations associated with Long Range Strike WSEP missions indicate the potential for Level B (TTS and Behavioral) harassment, and take is requested for this level of impact. It is expected that the mitigation measures identified in Section 11 will decrease the potential for impacts. The subsequent analyses in this request will identify the applicable types of take.

As mentioned in previous sections, this IHA is requested only for missions occurring September 1, 2016, which include deployment of one JASSM/JASSM-ER and up to eight SDBs with all detonations occurring at the water surface. Follow-on testing is planned for the timeframe of 2017 to 2021, and will include additional weapons and detonation scenarios. However, these follow-on missions are analyzed in a separate LOA request. The 2016 missions have been identified as an immediate need. All combined missions (2016 to 2021) are included in analyses contained in the associated EA/OEA. In addition to protections provided to all marine mammals by the MMPA, some species are also listed under the ESA (see Table 4-2). Potential impacts to species listed under the ESA are further analyzed in a separate Biological Assessment, prepared by the Air Force pursuant to Section 7 of the ESA.

This page is intentionally blank.

6.0 NUMBERS AND SPECIES TAKEN

Potential impacts to marine mammals resulting from Long Range Strike WSEP missions, including munition strikes, ingestion of military expended materials, and detonation effects (overpressure and acoustic components), are discussed in the following subsections.

6.1 Physical Strike

Marine mammals could be physically struck by weapons during Long Range Strike WSEP missions. A total of nine weapons (one JASSM and eight SDBs) will be released during the one 2016 mission day. The velocity of falling objects, including bombs and missiles, decreases quickly after striking the water, and, therefore, injury and mortality are considered unlikely for animals swimming in the water column at depths of more than a few meters. Strike potential would generally be limited to animals located at the water surface or in the water column near the surface. Strike potential would be further reduced by pre-mission surveys, avoidance of observed marine mammals in the mission area, and the generally dispersed distribution of marine mammals. Although the probability of a direct strike by test weapons is not quantified, the Air Force considers it to be low.

6.2 Ingestion Stressors

Military expended materials that would be produced during Long Range Strike WSEP missions include inert munitions and fragments of exploded bombs and missiles. Intact, inert munitions would be too large to ingest. However, some munition fragments could be ingested by some species, possibly resulting in injury or death.

A small quantity of exploded weapons components, such as small plastic pieces, could float on the surface. Species feeding at the surface could incidentally ingest these floating items. Sei whales are known to skim feed, and there is potential for other species to feed at the surface. Laist (1997) provides a review of numerous marine mammal species that have been documented to ingest debris, including 21 odontocetes. Most of these species had apparently ingested debris floating at the surface. A marine mammal would suffer a negative impact from military expended materials if the item becomes imbedded in tissue or is too large to pass through the digestive system. Some of the items would be small enough to pass through an animal's digestive system without harm. In addition, an animal would not likely ingest every expended item it encountered. The number of items at the surface encountered by a given animal would be decreased by the low initial density of items and dispersal by currents and wind. Due to the small amount of floating military expended materials produced and the dispersed nature of marine mammals and marine mammal groups potentially encountering an item at the surface, floating military expended materials are unlikely to negatively affect marine mammals.

Most military expended materials would not remain on the water surface but would sink at various rates of speed, depending on the density and shape of the item. Individual marine mammals feeding in the water column (for example, dolphins preying on fish or squid at middle depths) could potentially ingest a sinking item. Most items would sink relatively quickly and would not remain suspended in the water column indefinitely. In addition, not all items encountered would be ingested, as a marine mammal would probably be able to distinguish military expended materials from prey in many instances. Overall, sinking items are not expected to present a substantial ingestion threat to marine mammals.

Most of the military expended materials resulting from Long Range Strike WSEP missions would sink to the bottom and would probably eventually become encrusted and/or covered by sediments, although cycles of covering/exposure could occur due to water currents. Several marine mammal species feed at or near the seafloor. For example, although sperm whales feed primarily on squid (presumably deep in the water column), demersal fish species are also sometimes consumed. Humpback whales may also feed near the bottom, and beaked whales use suction feeding to ingest benthic prey. Hawaiian monk seals feed on numerous species that may occur on or near the seafloor, including fish, cephalopods, and lobsters. Therefore, there is some potential for such species to incidentally ingest military expended materials while feeding. However, the potential for such encounters is low based on the relatively low number and patchy distribution of the items produced, the patchy distribution of marine mammal feeding habitat, and water depth at the impact location (over 4,000 meters). Further, an animal would not likely ingest every military expended material it encounters. Animals may attempt to ingest an item and then reject it after realizing it is not a food item. Additionally, ingestion of an item would not necessarily result in injury to mortality to the individual if the item does not become embedded in tissue (Wells et al., 2008). Therefore, impacts resulting from ingestion of military expended materials would be limited to the unlikely event where a marine mammal suffers a negative response from ingesting an item that becomes embedded in tissue or is too large to pass through the digestive system. Military expended materials that become encrusted or covered by sediments would have a lower potential for ingestion. In general, it is not expected that large numbers of items on the seafloor would be consumed and result in harm to marine mammals, particularly given the water depth at the impact location. Based on the discussion above, the Air Force considers potential impacts unlikely and population-level effects on any species are considered remote.

6.3 Detonation Effects

Cetaceans spend their entire lives in the water and are submerged below the surface much of the time. When at the surface, unless engaging in behaviors such as jumping, spyhopping, etc., the body is almost entirely below the water's surface, with only the blowhole exposed to allow breathing. This can make cetaceans difficult to locate visually and also exposes them to underwater noise, both natural and anthropogenic, most of the time because their ears are nearly always below the water's surface. Hawaiian monk seals spend some portion of their time out of the water. However, when swimming under the surface (e.g., during foraging dives), seals are also exposed to natural and anthropogenic noise. As a result, marine mammals located near a surface detonation could be exposed to the resulting shock wave and acoustic energy. Potential effects include mortality, injury, impacts to hearing, and behavioral disturbance.

The potential numbers and species of marine mammal exposures are assessed in this section. Appendix A provides a description of the acoustic modeling methodology used to estimate exposures, as well as the model outputs. Three sources of information are necessary for estimating potential acoustic effects on marine mammals: (1) the zone of influence, which is the distance from an explosion to which particular levels of impact would extend; (2) the density of animals within the zone of influence; and (3) the number of detonations (events). Each of these components is described in the following subsections.

Zone of Influence

The zone of influence is defined as the area or volume of ocean in which marine mammals could be exposed to various pressure or acoustic energy levels caused by exploding ordnance. Refer to Appendix A for a description of the method used to calculate impact volumes for explosives. The pressure and energy levels considered to be of concern are defined in terms of metrics, criteria, and thresholds. A *metric* is a technical standard of measurement that describes the acoustic environment (e.g., frequency duration, temporal pattern, and amplitude) and pressure at a given location. *Criteria* are the resulting types of possible impact and include mortality, injury, and harassment. A *threshold* is the level of pressure or noise above which the impact criteria are reached. The analysis of potential impacts to marine mammals incorporates criteria and thresholds presented in Finneran and Jenkins (2012). The paragraphs below provide a general discussion of the various metrics, criteria, and thresholds used for impulsive noise impact assessment. More detailed information is provided in Appendix A.

Metrics

Standard impulsive and acoustic metrics were used for the analysis of underwater energy and pressure waves in this document. Several different metrics are important for understanding risk assessment analysis of impacts to marine mammals.

SPL (sound pressure level): A ratio of the absolute sound pressure to a reference level. Units are in decibels referenced to 1 micropascal (dB re 1 μPa).

SEL (sound exposure level): SEL is a measure of sound intensity and duration. When analyzing effects on marine animals from multiple moderate-level sounds, it is necessary to have a metric that quantifies cumulative exposures. SEL can be thought of as a composite metric that represents both the intensity of a sound and its duration. SEL is determined by calculating the decibel level of the cumulative sum-of-squared pressures over the duration of a sound, with units of decibels referenced to 1 micropascal-squared seconds (dB re 1 $\mu Pa^2 \cdot s$) for sounds in water.

Positive impulse: This is the time integral of the pressure over the initial positive phase of an arrival. This metric represents a time-averaged pressure disturbance from an explosive source. Units are typically pascal-seconds (Pa·s) or pounds per square inch per millisecond (psi·msec). There is no decibel analog for impulse.

Criteria and Thresholds

The criteria and thresholds used to estimate potential pressure and acoustic impacts to marine mammals resulting from detonations were obtained from Finneran and Jenkins (2012) and include mortality, injurious harassment (Level A), and non-injurious harassment (Level B). In some cases, separate thresholds have been developed for different species groups or functional hearing groups. Functional hearing groups included in the analysis are low-frequency cetaceans, mid-frequency cetaceans, high-frequency cetaceans, and phocids. A more detailed description of each of the criteria and thresholds is provided in Appendix A.

<u>Mortality</u>

Mortality risk assessment may be considered in terms of direct injury, which includes primary blast injury and barotrauma. The potential for direct injury of marine mammals has been inferred from terrestrial mammal experiments and from post-mortem examination of marine mammals believed to have been exposed to underwater explosions (Finneran and Jenkins, 2012; Ketten et al., 1993; Richmond et al., 1973). Actual effects on marine mammals may differ from terrestrial animals due to anatomical and physiological differences, such as a reinforced trachea and flexible thoracic cavity, which may decrease the risk of injury (Ridgway and Dailey, 1972).

Primary blast injuries result from the initial compression of a body exposed to a blast wave and is usually limited to gas-containing structures (e.g., lung and gut) and the auditory system (U.S. Department of the Navy, 2001). Barotrauma refers to injuries caused when large pressure changes occur across tissue interfaces, normally at the boundaries of air-filled tissues such as the lungs. Primary blast injury to the respiratory system may be fatal depending upon the severity of the trauma. Rupture of the lung may introduce air into the vascular system, producing air emboli that can restrict oxygen delivery to the brain or heart.

Whereas a single mortality threshold was previously used in acoustic impacts analysis, species-specific thresholds are currently required. Thresholds are based on the level of impact that would cause extensive lung injury resulting in mortality to 1 percent of exposed animals (that is, an impact level from which 1 percent of exposed animals would not recover) (Finneran and Jenkins, 2012). The threshold represents the expected onset of mortality, where 99 percent of exposed animals would be expected to survive. Most survivors would have moderate blast injuries. The lethal acoustic exposure level of a blast, associated with the positive impulse pressure of the blast, is expressed as Pa·s and is determined using the Goertner (1982) modified positive impulse equation. This equation incorporates source/animal depths and the mass of a newborn calf for the affected species. The threshold is conservative because animals of greater mass can withstand greater pressure waves, and newborn calves typically make up a very small percentage of any marine mammal group. While the mass of newborn calves for some species are provided in literature, in many cases this information is unknown and a surrogate species (considered to be generally comparable in mass) is used instead. Finneran and Jenkins (2012) provide known or surrogate masses for newborn calves of several cetacean species. The Goertner equation, as presented in Finneran and Jenkins (2012) is used in the acoustic model to develop impacts analysis in this IHA request. The equation is provided in Appendix A.

Injury (Level A Harassment)

Three categories of blast-related injury (Level A harassment) are currently recognized by NMFS: gastrointestinal (GI) tract injury, slight lung injury, and irrecoverable auditory damage (permanent threshold shift).

Gastrointestinal Tract Injuries. Though often secondary in life-threatening severity to pulmonary blast trauma, the GI tract can also suffer contusions and lacerations from blast exposure, particularly in air-containing regions of the tract. Although hemorrhage of solid organs (e.g., liver, spleen, and kidney) from blast exposure is possible, rupture of these organs is rarely encountered. GI tract injuries are correlated with the peak pressure of an underwater detonation. GI tract injury thresholds are based on the results of experiments in the 1970s in which terrestrial mammals were exposed to small charges. The peak pressure of the shock wave was found to cause recoverable contusions (bruises) in the GI tract (Richmond et al., 1973; in Finneran and Jenkins, 2012). The experiments found that a peak SPL of 237 dB re 1 μPa predicts the onset of GI tract injuries, regardless of an animal's mass or size. Therefore, the unweighted peak SPL of 237 dB re 1 μPa is used in explosive impacts assessments as the threshold for slight GI tract injury for all marine mammals.

Slight Lung Injury. This threshold is based on a level of exposure where most animals may experience slight blast injury to the lungs, but all would survive (zero percent mortality) (Finneran and Jenkins, 2012). Similar to the mortality determination, the metric is positive impulse and the equation for determination is that of the Goertner injury model (1982), corrected for atmospheric and hydrostatic pressures and based on the cube root scaling of body mass (Richmond et al., 1973; U.S. Department of the Navy, 2001). The equation is provided in Appendix A.

Auditory Damage (Permanent Threshold Shift). Another type of injury correlated to Level A harassment is permanent threshold shift (PTS), which is auditory damage that does not recover and results in a permanent decrease in hearing sensitivity. There have been no studies to determine the onset of PTS in marine mammals and, therefore, this threshold must be estimated from other available information. Finneran and Jenkins (2012) define separate PTS thresholds for three groups of cetaceans based on hearing sensitivity (low-frequency, mid-frequency, and high-frequency), and for phocids. Dual criteria are provided for PTS thresholds, one based on the SEL and one based on the SPL of an underwater blast. For a given analysis, the more conservative of the two is typically applied. The PTS thresholds are provided in Appendix A.

Non-Injurious Impacts (Level B Harassment)

Two categories of non-injurious Level B harassment are currently recognized: temporary threshold shift (TTS) and behavioral impacts. Although TTS is a physiological impact, it is not considered injury because auditory structures are temporarily fatigued instead of being permanently damaged.

Temporary Threshold Shift. Non-injurious effects on marine mammals, such as TTS, are generally extrapolated from data on terrestrial mammals (Southall et al., 2007). Similar to PTS, dual criteria are provided for TTS thresholds, and the more conservative is typically applied in impacts analysis. TTS criteria are based on data from impulse sound exposures when available. If impulse TTS data are not available, data from non-impulse exposures may be used (adjusted for the relationship between impulse and non-impulse TTS observed in dolphins and belugas). For species where no data exist, TTS thresholds are based on the most closely related species for which data are available. The TTS thresholds are provided in Appendix A.

Behavioral Impacts. Behavioral impacts refer to disturbances that may occur at acoustic levels below those considered to cause TTS in marine mammals, particularly in cases of multiple detonations. During an activity with a series of explosions (not concurrent multiple explosions), an animal is expected to exhibit a startle reaction to the first detonation followed by a behavioral response after multiple detonations. At close ranges and high sound levels, avoidance of the area around the explosions is the assumed behavioral response in most cases. Behavioral impacts may include decreased ability to feed, communicate, migrate, or reproduce, among others. Such effects, known as sub-TTS Level B harassment, are based on observations of behavioral reactions in captive dolphins and beluga whales exposed to pure tones, a different type of sound than that produced from a detonation (Finneran and Schlundt, 2004; Schlundt et al., 2000). Behavioral effects are generally considered to occur when animals are exposed to multiple, successive detonations at the same location within a 24-hour period. For single detonations, behavioral disturbance is likely limited to short-term startle reactions. The behavioral impacts thresholds for marine mammals exposed to multiple, successive detonations are provided in Appendix A.

Marine Mammal Density

Density estimates for marine mammals occurring in the Study Area are provided in Table 3-4. As discussed in Section 3, marine mammal density estimates were obtained from the U.S. Navy's Marine Species Density Database (U.S. Department of the Navy, 2014), which provides the most relevant and comprehensive density information for waters associated with the HRC. Density is typically reported for an area (e.g., animals per square kilometer). Density estimates usually assume that animals are uniformly distributed within the affected area, even though this is rarely true. Marine mammals may be clumped in areas of greater importance; for example, animals may be more concentrated in areas offering high productivity, lower predation, safe calving, etc. However, because there are usually insufficient data to calculate density for small areas, an even distribution is typically assumed for impact analyses.

Although the Study Area is depicted as only the surface of the water, in reality, density implicitly includes animals anywhere within the water column under that surface area. Assuming that marine mammals are distributed evenly within the water column does not accurately reflect animal behaviors. Databases of behavioral and physiological parameters obtained through tagging and other technologies have demonstrated that marine animals use the water column in various ways. Some species conduct regular deep dives while others engage in much shallower dives, regardless of bottom depth. Assuming that all species are evenly distributed from surface to bottom is almost never appropriate and can present a distorted view of marine mammal distribution in any region. Therefore, for purposes of this analysis, a depth distribution adjustment is applied to marine mammal densities. The depth distribution for each species included in the Study Area is provided in Appendix B. Combining marine mammal density with depth information would allow impact estimates to be based on three-dimensional density distributions, likely resulting in more accurate modeling of potential exposures. However, based on current regulatory guidance, density is assumed to be two-dimensional, and exposure estimates are therefore simply calculated as the product of affected area, density, and number of events. The resulting exposure estimates are considered conservative because all animals are presumed to be located at the same depth, where the maximum sound and pressure ranges would extend from detonations, and therefore be exposed to the maximum amount of energy or pressure. In reality, it is highly likely that marine mammals present near the impact area at the time of detonation would be at various depths in the water column, and not necessarily occur at the same depth corresponding to the maximum sound and pressure ranges.

Number of Events

An “event” refers to a single, unique action that has the potential to expose marine mammals to pressure and/or noise levels associated with take under the MMPA. For Long Range Strike WSEP activities, the number of events generally corresponds to the number of live ordnance items released within a 24-hour period. For 2016 missions, all live ordnance being released (Table 1-1) are proposed to occur on the same mission day, which would equate to a single event with multiple releases. Up to four SDBs may be released simultaneously and would detonate within a few seconds of each other in the same vicinity and is referred to as a “burst.” Under such a detonation scenario, the energy from all four munitions in the burst is summed, but the pressure component is not. For 2016 missions, one JASSM/JASSM-ER release and two SDB-I bursts (eight total SDB-I munitions) releases are proposed. The JASSM/JASSM-ER release would occur separately from each SDB-I burst release, but the total energy for all releases in a 24-hour period is summed for impact calculations. Refer to Appendix A for a detailed explanation of modeling methods.

Exposure Estimates

The maximum estimated range, or radius, from the detonation point to which the various thresholds extend for all munitions proposed to be released in a 24-hour time period was calculated based on explosive acoustic characteristics, sound propagation, and sound transmission loss in the Study Area, which incorporates water depth, sediment type, wind speed, bathymetry, and temperature/salinity profiles (Table 6-1). The ranges were used to calculate the total area (circle) of the zones of influence for each criterion/threshold. To eliminate “double-counting” of animals, impact areas from higher impact categories (e.g., mortality) were subtracted from areas associated with lower impact categories (e.g., Level A harassment). The estimated number of marine mammals potentially exposed to the various impact thresholds was then calculated as the product of the adjusted impact area, animal density, and number of events. Since the model accumulates the energy from all detonations within a 24-hour timeframe, it is assumed that the same population of animals is being impacted within that time period. The population would refresh after 24 hours. In this case, only one mission day is planned for 2016, and therefore, only one event is modeled that would impact the same population of animals. Details of the acoustic modeling method are provided in Appendix A.

The resulting total number of marine mammals potentially exposed to the various levels of thresholds is shown in Table 6-2. An animal is considered “exposed” to a sound if the received sound level at the animal’s location is above the background ambient acoustic level within a similar frequency band. The exposure calculations from the model output resulted in decimal values, suggesting in most cases that a fraction of an animal was exposed. To eliminate this, the acoustic model results were rounded to the nearest whole animal to obtain the exposure estimates from 2016 missions. For impact categories with multiple criteria and/or thresholds (e.g., three criteria and four thresholds associated with Level A harassment), numbers in the table are based on the threshold resulting in the greatest number of exposures. These exposure estimates do not take into account the required mitigation and monitoring measures described in Section 11 of this document, which may decrease the potential for impacts.

Table 6-1. Threshold Radii (in meters) for 2016 Long Range Strike WSEP Mission

Species	Mortality	Level A Harassment				Level B Harassment		
		Slight Lung Injury	GI Tract Injury	PTS		TTS		Behavioral
	Based on Goertner (1982)	Based on Richmond et al. (1973)	237 dB SPL	Applicable SEL*	Applicable SPL*	Applicable SEL*	Applicable SPL*	Applicable SEL*
Humpback Whale	38	81	165	2,161	330	6,565	597	13,163
Blue Whale	28	59	165	2,161	330	6,565	597	13,163
Fin Whale	28	62	165	2,161	330	6,565	597	13,163
Sei Whale	38	83	165	2,161	330	6,565	597	13,163
Bryde's Whale	38	81	165	2,161	330	6,565	597	13,163
Minke Whale	55	118	165	2,161	330	6,565	597	13,163
Sperm Whale	33	72	165	753	330	3,198	597	4,206
Pygmy Sperm Whale	105	206	165	6,565	3,450	20,570	6,565	57,109
Dwarf Sperm Whale	121	232	165	6,565	3,450	20,570	6,565	57,109
Killer Whale	59	126	165	753	330	3,198	597	4,206
False Killer Whale	72	153	165	753	330	3,198	597	4,206
Pygmy Killer Whale	147	277	165	753	330	3,198	597	4,206
Short-finned Pilot Whale	91	186	165	753	330	3,198	597	4,206
Melon-headed Whale	121	228	165	753	330	3,198	597	4,206
Bottlenose Dolphin	121	232	165	753	330	3,198	597	4,206
Pantropical Spotted Dolphin	147	277	165	753	330	3,198	597	4,206
Striped Dolphin	147	277	165	753	330	3,198	597	4,206
Spinner Dolphin	147	277	165	753	330	3,198	597	4,206
Rough-toothed Dolphin	121	232	165	753	330	3,198	597	4,206
Fraser's Dolphin	110	216	165	753	330	3,198	597	4,206
Risso's Dolphin	85	175	165	753	330	3,198	597	4,206
Cuvier's Beaked Whale	51	110	165	753	330	3,198	597	4,206
Blainville's Beaked Whale	79	166	165	753	330	3,198	597	4,206
Longman's Beaked Whale	52	113	165	753	330	3,198	597	4,206
Hawaiian Monk Seal	135	256	165	1,452	1,107	3,871	1,881	6,565

dB = decibel; GI = gastrointestinal; JASSM = Joint Air-to-Surface Standoff Missile; JASSM-ER = Joint Air-to-Surface Standoff Missile Extended Range; lbs = pounds; PTS = permanent threshold shift; SDB = Small Diameter Bomb; SEL = sound exposure level; SPL = sound pressure level; TTS = temporary threshold shift
*Based on the applicable Functional Hearing Group

Table 6-2. Number of Marine Mammals Potentially Affected by 2016 Long Range Strike WSEP Missions

Species	Mortality (Criterion)	Level A Harassment (PTS)	Level B Harassment (TTS)	Level B Harassment (Behavioral)
Mysticetes (baleen whales)				
Humpback whale	0	0	0	0
Blue whale	0	0	0	0
Fin whale	0	0	0	0
Sei whale	0	0	0	0
Bryde's whale	0	0	0	0
Odontocetes (toothed whales and dolphins)				
Sperm whale	0	0	0	0
Pygmy sperm whale	0	0	3	26
Dwarf sperm whale	0	1	9	64
Killer whale	0	0	0	0
False killer whale	0	0	0	0
Pygmy killer whale	0	0	0	0
Short-finned pilot whale	0	0	0	0
Melon-headed whale	0	0	0	0
Bottlenose dolphin	0	0	0	0
Pantropical spotted dolphin	0	0	0	0
Striped dolphin	0	0	0	0
Spinner dolphin	0	0	0	0
Rough-toothed dolphin	0	0	0	0
Fraser's dolphin	0	0	0	0
Risso's dolphin	0	0	0	0
Cuvier's beaked whale	0	0	0	0
Blainville's beaked whale	0	0	0	0
Longman's beaked whale	0	0	0	0
Pinnipeds				
Hawaiian monk seal	0	0	0	0
Total	**0**	**1**	**12**	**90**

PTS = permanent threshold shift; TTS = temporary threshold shift; WSEP = Weapon Systems Evaluation Program

7.0 IMPACTS TO MARINE MAMMAL SPECIES OR STOCKS

A variety of effects may result from exposure to sound-producing activities. The severity of the effects can range from minor effects with no real cost to the animal to more severe effects that may have lasting consequences. The types of effects potentially experienced by marine mammals, as well as the estimated number of animals potentially affected, is provided in the following paragraphs. None of the estimates take into account the mitigation measures outlined in Section 11, which are expected to reduce the number and severity of effects. Impacts are expected to be recoverable; therefore, no adverse population level effects are anticipated.

Marine mammal species for which exposure to any threshold is estimated to more than half an animal due to Long Range Strike WSEP activities include pygmy sperm whale and dwarf sperm whale. Individuals from these species are associated with the Hawaii stocks, and none are listed under the ESA or considered depleted under the MMPA. Based on acoustic modeling results described in Section 6, no marine mammals would be exposed to pressure or energy levels associated with mortality, slight lung injury, or GI tract injury. Approximately 1 dwarf sperm whale could be exposed to energy levels associated with PTS. Additionally, 9 dwarf sperm whales and 3 pygmy sperm whales, could be experience TTS, and about 64 dwarf sperm whales and 26 pygmy sperm whales could experience behavioral effects (Table 6-2).

Auditory fatigue is a reduction in hearing ability resulting from overstimulation to sounds that may result from damage or distortion of the tympanic membrane and hair cells, hair cell death, changes in cochlear blood flow, and cochlear nerve swelling. Studies of terrestrial mammals show that large amounts of TTS (approximately 40 dB measured 24 hours after exposure) can result in permanent neural degeneration, despite the hearing thresholds returning to normal. Animals are most susceptible to auditory fatigue within their most sensitive hearing range. The greater the degree of threshold shift, the smaller the ocean space within which an animal can detect biologically relevant sounds. In this document, the SEL metric resulted in the higher TTS exposure estimates and was used to determine takes.

Behavioral harassment occurs at distances beyond the range of structural damage and hearing threshold shift. Numerous behavioral responses can result from physiological responses. An animal may react to a stimulus based on a number of factors in addition to the severity of the physiological response. An animal's previous experience with the same or a similar sound, the context of the exposure, and the presence of other stimuli contribute to determining its reaction. Behavioral responses fall into two major categories: alterations in natural behavior patterns and avoidance. These types of reactions are not mutually exclusive, and overall reactions may be combinations of behaviors or a sequence of behaviors. Severity of behavioral reactions can vary substantially, from minor and brief reorientations of the animal to investigate the sound to severe reactions such as aggression or prolonged flight. The type and severity of the behavioral response will determine the energetic cost to the animal. Possible behavioral responses to a detonation include panic, startle, departure from an area, and disruption of activities such as feeding or breeding, among others.

The magnitude and type of effect, as well as the speed and completeness of recovery, affect the long-term consequences to individual animals and populations. Animals that recover quickly and completely from explosive effects will not likely suffer reductions in their health or reproductive success, or experience changes in their habitat utilization. In such cases, no population-level effects would be expected. Animals that do not recover quickly and fully could suffer reductions in their health and reproductive success; they could be permanently displaced or change how they utilize the environment; or they could die. Frequent disruptions to natural behavior patterns may not allow an animal to fully recover between exposures, which increases the probability of causing long-term consequences to individuals. Long-term consequences to individuals can lead to population level consequences.

Consideration of "negligible impact" is required by NMFS to authorize incidental take of marine mammals. An activity has a negligible impact on a species or stock when it is determined that the total taking is not likely to reduce annual rates of adult survival or recruitment (offspring survival, birth rates). Potential impacts associated with the proposed actions consist only of TTS and behavioral effects (Level B harassment) for two marine mammal species. Behavioral reactions of marine mammals to sound are known to occur but are difficult to predict. Behavioral studies indicate that reactions to sounds, if any, are highly contextual and vary between species and individuals within a species (Moretti et al., 2010; Southall et al., 2011; Thompson et al, 2010; Tyack, 2009a; Tyack et al., 2011). Depending on the context, marine mammals often change their activity when exposed to disruptive levels of sound. When attempting to understand behavioral disruption by anthropogenic sound, a key consideration is whether the exposures have biologically significant consequences for the individual or population (National Research Council of the National Academies, 2005).

If a marine mammal does react to an underwater sound by changing its behavior or moving a small distance, the impacts of the change may not be important to the individual. For example, researchers have found during a study of dolphins response to whale watching vessels in New Zealand that when animals can cope with constraint and easily feed or move elsewhere, there is little effect on survival (Lusseau and Bejder, 2007). On the other hand, if a sound source displaces marine mammals from an important feeding or breeding area for a prolonged period and they do not have an alternate equally desirable area, impacts on the marine mammal could be negative because the disruption has biological consequences. Biological parameters or key elements having greatest importance to a marine mammal relate to its ability to mature, reproduce, and survive.

The importance of the disruption and degree of consequence for individual marine mammals is often dependent on the frequency, intensity, and duration of the disturbance. Isolated acoustic disturbances such as underwater detonations are expected to have minimal consequences and no lasting consequences on marine mammal populations. Marine mammals regularly cope with occasional disruption of their activities by predators, adverse weather, and other natural phenomena. It is reasonable to assume that they can tolerate occasional or brief disturbances by anthropogenic sound without significant consequences.

In summary, the following points provide a context for evaluating the potential to impact individual marine mammals or marine mammal populations during Long Range Strike WSEP activities in 2016:

- Estimated mortality impacts are zero.
- Most acoustic harassment effects are within the non-injurious TTS or behavioral effects zones (Level B harassment); the estimated number of animals potentially affected by Level A harassment (PTS only) is small.
- The take numbers presented in Section 6 and summarized in the preceding paragraphs are likely conservative (overestimates) because they do not take into account the mitigation measures described in Section 11. These measures are expected to decrease the potential for acoustic impacts. In addition, exposure calculations are based on the assumption that all animals would occupy the same depth within the water column, and do not take into account diving behavior which could decrease exposure levels.

8.0 IMPACT ON SUBSISTENCE USE

Potential marine mammal impacts resulting from the proposed activities will be limited to individuals located in the Study Area and that have no subsistence requirements. Therefore, no impacts on the availability of species or stocks for subsistence use are considered.

9.0 IMPACTS TO MARINE MAMMAL HABITAT AND THE LIKELIHOOD OF RESTORATION

The primary sources of marine mammal habitat impact are acoustic and pressure waves resulting from live weapon detonations. However, neither the sound nor overpressure constitutes a long-term physical alteration of the water column or ocean floor. Further, these effects are not expected to substantially affect prey availability, are of limited duration, and are intermittent in time. Therefore, it is not anticipated that marine mammals will stop utilizing the waters of the Study Area, either temporarily or permanently, as a result of mission activities.

Other factors that could potentially affect marine mammal habitat include the introduction of metals, explosives and explosion by-products, other chemical materials, and debris into the water column and substrate due to the use of munitions; and effect to prey distribution. The effects of metals, explosives and explosion by-products, other chemical materials, and debris are analyzed in the associated Long Range Strike WSEP EA/OEA, prepared in accordance with the National Environmental Policy Act. Based on the review in the EA/OEA, there would be no significant effects to marine mammals resulting from loss or modification of marine mammal habitat including water and sediment quality. Refer to the EA/OEA for more detailed discussion of these components.

Marine mammals in the Study Area feed on various fish and invertebrates. Physical effects from pressure and acoustic waves generated by surface detonations could affect these prey species near the detonation point, potentially decreasing their availability to marine mammals. In particular, the rapid oscillation between high and low-pressure peaks has the potential to burst the swim bladders and other gas-containing organs of fish (Keevin and Hemen, 1997). Sublethal effects, such as changes in behavior of fish, have been observed in several occasions as a result of noise produced by explosives (National Research Council, 2003; Wright, 1982). The abundances of various fish and invertebrates near the detonation point could be altered for a few hours before animals from surrounding areas repopulate the area; however, these populations would be replenished as waters near the detonation point are mixed with adjacent waters. Munition fragments resulting from testing activities could potentially result in minor long-term changes to benthic habitat. Similar to an artificial reef structure, such materials could be colonized over time by benthic organisms that prefer hard substrate and could provide structure that could attract some species of fish.

10.0 IMPACTS TO MARINE MAMMALS FROM LOSS OR MODIFICATION OF HABITAT

Based on the discussions in Section 9, the proposed activities are not expected to have any habitat-related effects, such as from water quality, sediment quality, and prey availability, that could cause significant or long-term consequences for individual marine mammals or their populations. No permanent loss of modification of habitat would occur and there would be no indirect impacts to marine mammals from temporarily altered habitat conditions. There will be no long-term impacts on marine mammals resulting from loss or modification of marine mammal habitat.

11.0 MEANS OF AFFECTING THE LEAST PRACTICABLE ADVERSE IMPACTS

The potential takes discussed in Section 6 represent the maximum expected number of animals that could be exposed to particular acoustic thresholds. The impact estimates do not take into account measures that will be employed to minimize impacts to marine species. Unlike standard operating procedures, which are established for reasons other than environmental benefit, mitigation measures are modifications to the proposed activities that are implemented for the sole purpose of reducing a specific potential environmental impact on a particular resource. The procedures discussed in this section are, in general, routinely implemented for test events in the PMRF as a result of previous U.S. Navy environmental compliance documents, ESA biological opinions, MMPA incidental harassment authorizations or letters of authorization, or other formal or informal consultations with regulatory agencies. The Air Force has worked with PMRF personnel to ensure mitigation measures are adequate and meet NMFS' expectations based on requirements identified for past similar actions conducted in the PMRF and BSURE areas. The overall approach to assessing potential mitigation measures in the BSURE area is based on two principles: (1) mitigations will be effective at reducing potential impacts on the resource, and (2) mitigation is consistent with mission objectives, range procedures, and safety measures.

11.1 Mitigation Procedures

For missions involving air-to-surface weapon employment in the BSURE area, such as Long Range Strike WSEP activities, mitigation procedures consist of visual aerial surveys of the impact area for the presence of protected marine species (marine mammals and sea turtles). During aerial observation, Navy test range personnel may survey the area from an S-61N helicopter or C-62 aircraft that is based at the PMRF land facility (typically when missions are located relatively close to shore). Alternatively, when missions are located farther offshore, surveys may be conducted from mission aircraft (typically jet aircraft such as F-15E, F-16, or F-22) or a U.S. Coast Guard C-130 aircraft.

Protected species surveys typically begin within one hour of weapon release and as close to the impact time as feasible, given human safety requirements. Survey personnel must depart the human hazard zone before weapon release, in accordance with Navy safety standards. Personnel conduct aerial surveys within an area defined by an approximately 2-NM (3,704 m) radius around the impact point, with surveys typically flown in a star pattern. This survey distance is consistent with requirements already in place for similar actions at PMRF and encompasses the entire TTS threshold ranges (SEL) for all mid-frequency cetacean species (Table 6-1). For species in which potential exposures have been calculated (dwarf sperm whale and pygmy sperm whale), the survey distance would cover over half of the PTS SEL range for dwarf sperm and pygmy sperm whales. Given operational constraints, surveying larger areas would not be feasible.

Observers would consist of aircrew operating the C-26, S-61N, and C-130 aircraft from PMRF and the Coast Guard. These aircrew are trained and experienced at conducting aerial marine mammal surveys and have provided similar support for other missions at PMRF. Aerial surveys are typically conducted at an altitude of about 200 feet, but altitude may vary somewhat depending on sea state and atmospheric conditions. If adverse weather conditions preclude the ability for aircraft to safely operate, missions would either be delayed until the weather clears or cancelled for the day. For 2016 Long Range Strike WSEP missions, one day has been designated as a weather back-up day. The C-26 and other aircraft would generally be operated at a slightly higher altitude than the helicopter. The observers will be provided with the GPS location of the impact area. Once the aircraft reaches the impact area, pre-mission surveys typically last for 30 minutes, depending on the survey pattern. The fixed-wing aircraft are faster than the helicopter, and, therefore, protected species may be more difficult to spot. However, to compensate for the difference in speed, the aircraft may fly the survey pattern multiple times.

If a protected species is observed in the impact area, weapon release would be delayed until one of the following conditions is met: (1) the animal is observed exiting the impact area, (2) the animal is thought to have exited the impact area based on its course and speed, or (3) the impact area has been clear of any additional sightings for a period of 30 minutes. All weapons will be tracked and their water entry points will be documented. Post-mission surveys would begin immediately after the mission is complete and the Range Safety Officer declares the human safety area is reopened. Approximate transit time from the perimeter of the human safety area to the weapon impact area would depend on the size of the human safety area and vary between aircraft, but is expected to be less than 30 minutes. Post-mission surveys would be conducted by the same aircraft and aircrew that conducted the pre-mission surveys and would follow the same patterns as pre-mission surveys, but would focus on the area down current of the weapon impact area to determine if protected species were affected by the mission (observation of dead or injured animals). If an injury or mortality occurs to a protected species due to Long Range Strike WSEP missions, NMFS would be notified immediately.

12.0 MINIMIZATION OF ADVERSE EFFECTS ON SUBSISTENCE USE

Subsistence use is the traditional exploitation of marine mammals by native peoples (i.e., for their own consumption) inhabiting Arctic regions. In terms of the Long Range Strike WSEP IHA application, none of the proposed activities occur in or near the Arctic. Based on discussions in Section 7, there are no anticipated impacts on any species or stocks migrating through the Study Area that might be available for subsistence use.

13.0 MONITORING AND REPORTING MEASURES

For Long Range Strike WSEP missions using live ordnance, the impact area will be visually surveyed for marine mammal presence prior to commencement of activities. Pre-mission surveys will be conducted from an S-61N helicopter, U.S. Coast Guard AC-130, jet aircraft, or C-62 aircraft. Post-mission surveys will also be carried out by the same aircraft. If any marine mammals are detected during pre-mission surveys, activities will be immediately halted until the area is clear of all marine mammals, as described in Section 11. During post-mission surveys, if an animal is found to have been injured or otherwise adversely impacted, NMFS will be notified.

14.0 RESEARCH

Although the Air Force has conducted or supported marine species research in some areas of operation (for example, in the nearshore Gulf of Mexico where similar live air-to-surface testing and training occurs), the Air Force does not conduct research within the Navy's HRC.

15.0 LIST OF PREPARERS

Amanda Robydek, Environmental Scientist
Leidos
Eglin AFB Natural Resources
107 Highway 85 North
Niceville, FL 32578
(850) 882-8395
amanda.robydek.ctr@us.af.mil

Rick Combs, Marine Scientist
Leidos
1140 Eglin Parkway
Shalimar, FL 32579
(850) 609-3459
ronald.r.combs@leidos.com

Brian Sperry, Senior Scientist
Leidos
4001 N Fairfax Dr., Suite 600
Arlington, VA 22203
(703) 907-2551
brian.j.sperry@leidos.com

16.0 LITERATURE CONSIDERED AND REFERENCES CITED

Acevedo-Gutiérrez, A., D. A. Croll, and B. R. Tershy. (2002). "High feeding costs limit dive time in the largest whales." Journal of Experimental Biology 205: 1747-1753.

Aschettino, J.M. 2010. *Population size and structure of melon-headed whales (Peponocephala electra) around the main Hawaiian Islands: evidence of multiple populations based on photographic data*. Master's Thesis. Hawaii Pacific University.

Afsal, V. V., P. P. Manojkumar, K. S. S. M. Yousuf, B. Anoop and E. Vivekanandan (2009). "The first sighting of Longman's beaked whale, *Indopacetus pacificus* in the southern Bay of Bengal." Marine Biodiversity Records 2: 1-3.

Aguayo, L. A. and T. R. Sanchez. (1987). "Sighting records of Fraser's dolphin in the Mexican Pacific waters." Scientific Reports of the Whales Research Institute 38: 187-188.

Aguilar, A. (2008). Fin whale *Balaenoptera physalus*. In. Encyclopedia of Marine Mammals. W. F. Perrin, B. Wursig and J. G. M. Thewissen. Amsterdam, Academic Press**:** 433-437.

Aguilar Soto, N., M. P. Johnson, P. T. Madsen, F. Diaz, I. Dominguez, A. Brito and P. Tyack. (2008). "Cheetahs of the deep sea: Deep foraging sprints in short-finned pilot whales off Tenerife (Canary Islands)." Journal of Animal Ecology 77(5): 936-947.

Aissi, M., A. Celona, G. Comparetto, R. Mangano, M. Wurtz and A. Moulins. (2008). "Large-scale seasonal distribution of fin whales (Balaenoptera physalus) in the central Mediterranean Sea." Journal of the Marine Biological Association of the United Kingdom 88: 1253-1261.

Allen, B.M., and R.P. Angliss, 2015. Stock Assessment Report. Humpback whale (*Megaptera novaengliae*): Central North Pacific Stock. NOAA Technical Memorandum NOAA-TM-AFSC-301. Revised 10/09/2014.

Allen, B. M. and R. P. Angliss (2013). *Alaska Marine Mammal Stock Assessments 2012*. NOAA Technical Memorandum NMFS-AFSC-245, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center**:** 282.

Alonso, M. K., S. N. Pedraza, A. C. M. Schiavini, R. N. P. Goodall and E. A. Crespo. (1999). "Stomach contents of false killer whales (*Pseudorca crassidens*) stranded on the coasts of the Strait of Magellan, Tierra del Fuego." Marine Mammal Science 15(3): 712-724.

Alves, F., A. Dinis, I. Cascao and L. Freitas. (2010). "Bryde's whale (*Balaenoptera brydei*) stable associations and dive profiles: New insights from foraging behavior." Marine Mammal Science 26(1): 202-212.

Anderson, R. C., R. Clark, P. T. Madsen, C. Johnson, J. Kiszka and O. Breysse. (2006). "Observations of Longman's beaked whale (*Indopacetus pacificus*) in the Western Indian Ocean." Aquatic Mammals 32(2): 223-231.

Antonelis, G. A., J. D. Baker, T. C. Johanos, R. C. Braun and A. L. Harting. (2006). "Hawaiian monk seal (*Monachus schauinslandi*): Status and conservation issues." Atoll Research Bulletin 543: 75-101.

Archer, F. I. and W. F. Perrin. (1999). "Stenella coeruleoalba." Mammalian Species 603: 1-9.

Au, D. W. K. and W. L. Perryman. (1985). "Dolphin habitats in the eastern tropical Pacific." Fishery Bulletin 83: 623-643.

Ayres, K. l. R. K. Booth, J. A. Hempelmann, K. L. Koski, C. K. Emmons, R. W. Baird, K. Balcomb-Bartok, M. B. Hanson, M. J. Ford, S. K. Wasser (2012). Distinguishing the Impacts of Inadequate Prey and Vessel Traffic on an Endangered Killer Whale (Orcinus orca) Population. PLoS ONE:7(6), pp 12.

Azzellino, A., S. Gaspari, S. Airoldi and B. Nani (2008). "Habitat use and preferences of cetaceans along the continental slope and the adjacent pelagic waters in the western Ligurian Sea." Deep Sea Research I 55: 296–323.

Baird, R. W. (2009a). *A review of false killer whales in Hawaiian waters: Biology, status, and risk factors*. Olympia, WA, Cascadia Research Collective**:** 41.

Baird, R. W. (2009b). False killer whale *Pseudorca crassidens*. In. Encyclopedia of Marine Mammals (Second Edition). W. F. Perrin, B. Wursig and J. G. M. Thewissen, Academic Press**:** 405-406.

Baird, R. W. (2006). "Hawai'i's other cetaceans." Whale and Dolphin Magazine 11: 28-31.

Baird, R. W. (2005). "Sightings of dwarf (*Kogia sima*) and pygmy (*K. breviceps*) sperm whales from the main Hawaiian Islands." Pacific Science 59: 461-466.

Baird, R. W., S. W. Martin, D. L. Webster, and B. L. Southall, 2014. *Assessment of Modeled Received Sound Pressure Levels and Movements of Satellite-Tagged Odontocetes Exposed to Mid-Frequency Active Sonar at the Pacific Missile Range Facility: February 2011 Through February 2013*. Prepared for U.S. Pacific Fleet, submitted to NAVFAC PAC by HDR Environmental, Operations and Construction, Inc.

Baird, R.W., D.L. Webster, J.M. Aschettino, G.S. Schorr, D.J. McSweeney. 2013. Odontocete cetaceans around the main Hawaiian Islands: Habitat use and relative abundance from small-boat sighting surveys. Aquatic Mammals 39:253-269.

Baird, R.W., D. L. Webster, G. S. Schorr, J. M. Aschettino, A. M. Gorgone, and S. D. Mahaffy (2012). "Movements and Spatial Use of Odontocetes in the Western Main Hawaiian Islands: Results from Satellite-Tagging and Photo-Identification off Kauai and Niihau in July/August 2011". Technical Report: NPS-OC-12-003CR; http://hdl.handle.net/10945/13855

Baird, R., G. Schorr, D. Webster, D. McSweeney, M. Hanson and R. Andrews (2010a). Movements and habitat use of Cuvier's and Blainville's beaked whales in Hawaii: results from satellite tagging in 2009/2010. C. Research. La Jolla, CA.

Baird, R. W., G. S. Schorr, D. L. Webster, D. J. McSweeney, M. B. Hanson and R. D. Andrews (2010b). "Movements and habitat use of satellite-tagged false killer whales around the main Hawaiian Islands." Endangered Species Research 10: 107-121.

Baird, R. W., A. M. Gorgone, D. J. McSweeney, A. D. Ligon, M. H. Deakos, D. L. Webster, G. S. Schorr, K. K. Martien, D. R. Salden and S. D. Mahaffy (2009a). "Population structure of island-associated dolphins: Evidence from photo-identiifcation of common bottlenose dolphins (*Tursiops truncatus*) in the main Hawaiian Islands." Marine Mammal Science 25(2): 251-274.

Baird, R. W., D. J. McSweeney, G. S. Schorr, S. D. Mahaffy, D. L. Webster, J. Barlow, M. B. Hanson, J. P. Turner and R. D. Andrews. (2009b). Studies of beaked whales in Hawai'i: Population size, movements, trophic ecology, social organization, and behaviour. In. Beaked Whale Research. S. J. Dolman, C. D. MacLeod and P. G. H. Evans, European Cetacean Society**:** 23-25.

Baird, R. W., D. L. Webster, S. D. Mahaffy, D. J. McSweeney, G. S. Schorr and A. D. Ligon. (2008a). "Site fidelity and association patterns in a deep-water dolphin: Rough-toothed dolphins (*Steno bredanensis*) in the Hawaiian Archipelago." Marine Mammal Science 24(3): 535-553.

Baird, R., D. McSweeney, C. Bane, J. Barlow, D. Salden, L. Antoine, R. LeDuc and D. Webster. (2006a). "Killer whales in Hawaiian waters: Information on population identity and feeding habits." Pacific Science 60(4): 523–530.

Baird, R. W., G. S. Schorr, D. L. Webster, D. J. McSweeney and S. D. Mahaffy. (2006b). Studies of beaked whale diving behavior and odontocete stock structure in Hawai'i in March/April 2006**:** 31.

Baird, R. W., A. M. Gorgone, D. L. Webster, D. J. McSweeney, J. W. Durban, A. D. Ligon, D. R. Salden and M. H. Deakos. (2005). False killer whales around the main Hawaiian Islands: An assessment of interisland movements and population size using individual photo-identification (*Pseudorca crassidens*). Report prepared under Order No. JJ133F04SE0120 from the Pacific Islands Fisheries Science Center, National Marine Fisheries Service, 2570 Dole Street, Honolulu, HI 96822. 24pgs. 2005.

Baird, R. W., D. L. Webster, D. J. McSweeney, A. D. Ligon and G. S. Schorr. (2005b). Diving behavior and ecology of Cuvier's (*Ziphius cavirostris*) and Blainville's beaked whales (*Mesoplodon densirostris*) in Hawai'i. La Jolla, CA.

Baird, R. W., M. B. Hanson, E. E. Ashe, M. R. Heithaus and G. J. Marshall (2003a). *Studies of Foraging in "Southern Resident" Killer Whales during July 2002: Dive Depths, Bursts in Speed, and the Use of a "Crittercam" System for Examining Sub-surface Behavior*. Seattle, WA, U.S. Department of Commerce, National Marine Fisheries Service, National Marine Mammal Laboratory**:** 18.

Baird, R. W., D. J. McSweeney, D. L. Webster, A. M. Gorgone and A. D. Ligon (2003b). Studies of odontocete population structure in Hawaiian waters: Results of a survey through the main Hawaiian Islands in May and June 2003. Seattle, WA, NOAA**:** 25.

Baird, R. W., Ligon, A. D., Hooker, S. K. & Gorgone, A. M. (2001). Subsurface and nighttime behaviour of pantropical spotted dolphins in Hawai'i. *Canadian Journal of Zoology, 79*(6), 988-996.

Baker, J. D. (2008). "Variation in the relationship between offspring size and survival provides insight into causes of mortality in Hawaiian monk seals." Endangered Species Research 5: 55-64.

Baker, J. D. (2004). "Evaluation of closed capture-recapture methods to estimate abundance of Hawaiian monk seals." Ecological Applications 14: 987-998.

Baker, J. D. and T. C. Johanos (2004). "Abundance of the Hawaiian monk seal in the main Hawaiian Islands." Biological Conservation 116(1): 103-110.

Baker, A. N. and B. Madon (2007). "Bryde's whales (Balaenoptera cf. brydei Olsen 1913) in the Hauraki Gulf and northeastern New Zealand waters." Science for Conservation 272: 4-14.

Baker, J. D., A. L. Harting and T. C. Johanos (2006). "Use of discovery curves to assess abundance of Hawiian monk seals." Marine Mammal Science 22(4): 847-861.

Balcomb, K.C. (1987). The whales of Hawaii, including all species of marine mammals in Hawaiian and adjacent waters. San Francisco: Marine Mammal Fund.

Baldwin, R. M., M. Gallagher and K. Van Waerebeek. (1999). A review of cetaceans from waters off the Arabian Peninsula. In. The Natural History of Oman: A Festschrift for Michael Gallagher. M. Fisher, S. A. Ghazanfur and J. A. Soalton, Backhuys Publishers**:** 161-189.

Barlow, J. (2006). "Cetacean abundance in Hawaiian waters estimated from a summer/fall survey in 2002." Marine Mammal Science 22(2): 446-464.

Barlow, J. (2003). *Cetacean Abundance in Hawaiian Waters During Summer/Fall 2002*. La Jolla, CA, Southwest Fisheries Science Center, National Marine Fisheries Service and NOAA**:** 22.

Barlow, J. & Gisiner, R. (2006). Mitigating, monitoring and assessing the effects of anthropogenic sound on beaked whales. Journal of Cetacean Research and Management, 7(3), 239-249.

Barlow, J. Calambokidis, J. Falcone, E. A. Baker, C. S. Burdin, A. M. Clapham, P. J. Ford, J. K. B. Gabriele, C. M. LeDuc, R. Mattila, D. K. Quinn, T. J. II Rojas-Bracho, L. Straley, J. M. Taylor, B. L. Urban, J. R. Wade, P. Weller, D. Witteveen, B. H. Yamaguchi, M. (2011). Humpback whale abundance in the North Pacific estimated by photographic capture-recapture with bias correction from simulation studies. Marine Mammal Science, 1-26.

Barlow, J., M. Ferguson, E. Becker, J. Redfern, K. Forney, I. Vilchis, P. Fiedler, T. Gerrodette and L. Ballance (2009). Predictive Modeling of Cetacean Densities in the Eastern Pacific Ocean. NOAA-TMNMFS-SWFSC-444, Southwest Fisheries Science Center, La Jolla, California.

Barlow, J., S. Rankin, A. Jackson and A. Henry. (2008). *Marine Mammal Data Collected During the Pacific Islands Cetacean and Ecosystem Assessment Survey (PICEAS) Conducted Aboard the NOAA Ship McArthur II, July-November 2005*, NOAA**:** 27.

Barlow, J., M. C. Ferguson, W. F. Perrin, L. Ballance, T. Gerrodette, G. Joyce (2006). “Abundance and densities of beaked and bottlenose whales (family Ziphiidae).” Journal of Cetacean Research and Management 7(3): 263-270.

Barlow, J., S. Rankin, E. Zele and J. Appler (2004). *Marine Mammal Data Collected During the Hawaiian Islands Cetacean and Ecosystem Assessment Survey (HICEAS) Conducted Aboard the NOAA ships McArthur and David Starr Jordan, July-December 2002*, NOAA**:** 32.

Barros, N. B. and A. A. Myrberg (1987). “Prey detection by means of passive listening in bottlenose dolphins (*Tursiops truncatus*).” Journal of the Acoustical Society of America 82: S65.

Barros, N. B. and R. S. Wells (1998). “Prey and feeding patterns of resident bottlenose dolphins (*Tursiops truncatus*) in Sarasota Bay, Florida.” Journal of Mammalogy 79(3): 1045-1059.

Baumgartner, M. F. (1997). “The distribution of Risso’s dolphin (*Grampus griseus*) with respect to the physiography of the northern Gulf of Mexico.” Marine Mammal Science 13(4): 614-638.

Beatson, E. (2007). “The diet of pygmy sperm whales, Kogia breviceps, stranded in New Zealand: Implications for conservation.” Reviews in Fish Biology and Fisheries 17: 295-303.

Becker, E.A., K.A. Forney, D.G. Foley, J. Barlow (2012). “Density and spatial distribution patterns of cetaceans in the central North Pacific based on habitat models.” U.S. Department of Commerce NOAA Technical Memorandum NMFS-SWFSC-490, 34 p.

Benoit-Bird, K. J. (2004). “Prey caloric value and predator energy needs: Foraging predictions for wild spinner dolphins.” Marine Biology 145: 435-444.

Benoit-Bird, K. J. and W. W. L. Au (2003). “Prey dynamics affect foraging by a pelagic predator (*Stenella longirostris*) over a range of spatial and temporal scales.” Behavioral Ecology and Sociobiology 53: 364-373.

Benoit-Bird, K. J., W. W. Au, R. E. Brainard and M. O. Lammers (2001). “Diel horizontal migration of the Hawaiian mesopelagic boundary community observed acoustically.” Marine Ecology Progress Series 217: 1-14.

Bernard, H. J. and S. B. Reilly (1999). Pilot whales *Globicephala* Lesson, 1828. In. Handbook of Marine Mammals. S. H. Ridgway and R. Harrison. San Diego, CA, Academic Press. 6**:** 245-280.

Berzin, A. A. and V. L. Vladimirov (1981). “Changes in abundance of whalebone whales in the Pacific and Antarctic since the cessation of their exploitation.” Reports of the International Whaling Commission 31: 495-499.

Best, P. B. (1996). “Evidence of migration by Bryde’s whales from the offshore population in the southeast Atlantic.” Reports of the International Whaling Commission 46: 315-322.

Best, P. B. and C. H. Lockyer. (2002). “Reproduction, growth and migrations of sei whales *Balaenoptera borealis* off the west coast of South Africa in the 1960s.” South African Journal of Marine Science 24: 111-133.

Best, P. B., R. A. Rademeyer, C. Burton, D. Ljungblad, K. Sekiguchi, H. Shimada, D. Thiele, D. Reeb and D. S. Butterworth. (2003). “The abundance of blue whales on the Madagascar Plateau, December 1996.” Journal of Cetacean Research and Management 5(3): 253-260.

Best, P. B., D. S. Butterworth and L. H. Rickett. (1984). “An assessment cruise for the South African inshore stock of Bryde’s whales (*Balaenoptera edeni*).” Reports of the International Whaling Commission 34: 403-423.

Bloodworth, B. and D. K. Odell (2008). “Kogia breviceps.” Mammalian Species 819: 1-12.

Boggs, C. H., Oleson, E. M., Forney, K. A., Hanson, B., Kobayashi, D. R., Taylor, B. L., . . . Ylitalo, G. M. (2010). Status Review of Hawaiian Insular False Killer Whales (Pseudorca crassidens) under the Endangered Species Act. (NOAA Technical Memorandum NMFS-PIFSC-22, pp. 140 + Appendices) U. S. Department of Commerce and National Oceanic and Atmospheric Administration.

Bolle, L.J., C.A.F. de Jong, S.M. Bierman, P.J.G. van Beek, and O.A. van Keken, 2012. Common Sole Larvae Survive High Levels of Plie-Driving Sound inControlled Exposure Experiments. PLoS ONE 7(3): e33052. doi:10.1371/journal.pone.0033052

Bradford, A. L. and E. Lyman. 2015. Injury determinations for humpback whales and other cetaceans reported to NOAA response networks in the Hawaiian Islands during 2007-2012. U.S. Department of Commerce, NOAA Technical Memoranda, NOAA-TM-NMFS-PIFSC-45, 29p.

Bradford, A.L., K.A. Forney, E.M. Oleson, and J. Barlow. *In Review*. *Line-transect abundance estimates of cetaceans in the Hawaiian EEZ.* Fisheries Bulletin.

Bradford. A.L., K.A. Forney, E.M. Oleson, and J. Barlow. 2013. Line-transect abundance estimates of cetaceans in the Hawaiian EEZ. PIFSC Working Paper WP-13-004

Bradford, A. L., K. A. Forney, E. M. Oleson, and J. Barlow (2012). Line-transect abundance estimates of false killer whales (*Pseudorca crassidens*) in the pelagic region of the Hawaiian Exclusive Economic Zone and in the insular waters of the Northwestern Hawaiian Islands. Pacific Islands Fisheries Science Center, National Marine Fisheries Service, NOAA, Honolulu, HI 96822-2396. Pacific Islands Fish. Sci. Cent. Admin. Rep. H-12-02.

Brillinger, D. R., B. S. Stewart and C. S. Littnan. (2006). A meandering *hylje**. In Festschrift for Tarmo Pukkila on his 60th Birthday. E. P. Liski, J. Isotalo, J. Niemelä, S. Puntanen and G. P. H. Styan. Finland, Dept. of Mathematics, Statistics and Philosophy, University of Tampere**:** 79-92.

Bull, J. C., Jepson, P. D., Ssuna, R. K., Deaville, R., Allchin, C. R., Law, R. J. & Fenton, A. (2006). The relationship between polychlorinated biphenyls in blubber and levels of nematode infestations in harbour porpoises, Phocoena phocoena. Parasitology, 132, 565-573. doi:10.1017/S003118200500942X.

Calambokidis, J. (2009). Symposium on the results of the SPLASH humpback whale study: Final Report and Recommendations**:** 68.

Calambokidis, J., E.A. Falcone, T.J. Quinn, A.M. Burdin, P.J. Clapham, J.K.B. Ford, C.M. Gabriele, R. LeDuc, D. Mattila, L. Rojas-Bracho, J.M. Straley, B.L. Taylor, J. Urban R., D. Weller, B.H. Witteveen, M. Yamaguchi, A. Bendlin, D. Camacho, K. Flynn, A. Havron, J. Huggins, N. Maloney, J. Barlow, and P.R. Wade (2008). SPLASH: Structure of Populations, Levels of Abundance and Status of Humpback Whales in the North Pacific. Final report for Contract AB133F-03-RP-00078 prepared by Cascadia Research for U.S. Dept of Commerce.

Calambokidis, J., G. H. Steiger, J. M. Straley, S. Cerchio, D. R. Salden, J. R. Urban, J. K. Jacobsen, O. von Ziegesar, K. C. Balcomb, C. M. Gabriele, M. E. Dahlheim, S. Uchida, G. Ellis, Y. Miyamura, P. Ladron De Guevara, M. Yamaguchi, F. Sato, S. A. Mizroch, L. Schlender, K. Rasmussen, J. Barlow and T. J. Quinn II (2001). "Movements and population structure of humpback whales in the North Pacific." Marine Mammal Science 17(4): 769-794.

Caldwell, D. K. and M. C. Caldwell (1989). Pygmy sperm whale *Kogia breviceps* (de Blainville, 1838): Dwarf sperm whale *Kogia simus* Owen, 1866. In. Handbook of Marine Mammals. S. H. Ridgway and R. Harrison. San Diego, CA, Academic Press. 4: 234-260.

Canese, S., A. Cardinali, C. M. Foruntа, M. Giusti, G. Lauriano, E. Salvati and S. Greco (2006). "The first identified winter feeding ground of fin whales (Balaenoperta physalus) in the Mediterranean Sea." Journal of the Marine Biological Association of the United Kingdom 86(4): 903-907.

Canadas, A., R. Sagarminaga and S. Garcia-Tiscar. (2002). "Cetacean distribution related with depth and slope in the Mediterranean waters off southern Spain." Deep Sea Research I 49: 2053-2073.

Carretta, J.V., E.M. Oleson, D.W. Weller, A.R. Lang, K.A. Forney, J. Baker, M.M. Muto, B. Hanson, A.J. Orr, H. Huber, M.S. Lowry, J. Barlow, J.E. Moore, D. Lynch, L. Carswell, and R.L. Brownell Jr. (2015). U.S. Pacific Marine Mammal Stock Assessments: 2014. U.S. Department of Commerce, NOAA Technical Memorandum, NOAA-TMNMFS-SWFSC-549. 414 p.

Carretta, J. V., K. A. Forney, E. Oleson, K. Martien, M. M. Muto, M. S. Lowry, J. Barlow, J. Baker, B. Hanson, D. Lynch, L. Carswell, R. L. Brownell, J. Robbins, D. K. Mattila, K. Ralls and M. C. Hill. (2011). *U.S. Pacific Marine Mammal Stock Assessments: 2010*. La Jolla, CA, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center**:** 352.

Carretta, J. V., K. A. Forney, M. S. Lowry, J. Barlow, J. Baker, D. Johnston, B. Hanson, R. L. Brownell, Jr., J. Robbins, D. Mattila, K. Ralls, M. M. Muto, D. Lynch and L. Carswell. (2010). *U.S. Pacific Marine Mammal Stock Assessments: 2009. La Jolla, CA, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center: 336.*

Carretta, J. V., T. Price, D. Petersen and R. Read. (2005). "Estimates of marine mammal, sea turtle, and seabird mortality in the California drift gillnet fishery for swordfish and thresher shark, 1996-2002." Marine Fisheries Review 66(2): 21-30.

Cascadia Research. (2012a). *An update on our June/July 2012 Kaua'i field work,* Cascadia Research Collective. http://www.cascadiaresearch.org/hawaii/july2011.htm

Cascadia Research. (2012b). Beaked Whales in Hawai'i, Cascadia Research. http://www.cascadiaresearch.org/hawaii/beakedwhales.htm

Cascadia Research. (2010). *Hawai'i's false killer whales*, Cascadia Research. 2010.

Cetacean and Turtle Assessment Program. (1982). "A Characterization of Marine Mammals and Turtles in the Mid- and North Atlantic Areas of the U.S. Outer Continental Shelf." 540.

Chivers, S. J., R. W. Baird, K. M. Martien, B. L. Taylor, E. Archer, A. M. Gorgone, B. L. Hancock, N. M. Hedrick, D. Matilla, D. J. McSweeney, E. M. Oleson, C. L. Palmer, V. Pease, K. M. Robertson, J. Robbins, J. C. Salinas, G. Schorr, M. Schultz, J. L. Thieleking and D. L. Webster (2010). "Evidence of genetic differentiation for Hawaii insular false killer whales (*Pseudorca crassidens*)." NOAA Technical Report NMFS NOAA-TM-NMFS-SWFSC-458: 49.

Chivers, S. J., R. W. Baird, D. J. McSweeney, D. L. Webster, N. M. Hedrick and J. C. Salinas (2007). "Genetic variation and evidence for population structure in eastern North Pacific false killer whales (*Pseudorca crassidens*)." Canadian Journal of Zoology 85: 783-794.

Craig, A. S. and L. M. Herman (2000). "Habitat preferences of female humpback whales Megaptera novaeangliae in the Hawaiian Islands are associated with reproductive status." Marine Ecology Progress Series 193: 209-216.

Clapham, P. J. (2000). The humpback whale: seasonal feeding and breeding in a baleen whale. In. Cetacean Societies: Field Studies of Dolphins and Whales. J. Mann, R. C. Connor, P. L. Tyack and H. Whitehead, University of Chicago Press**:** 173-196.

Clapham, P. J. and D. K. Mattila (1990). "Humpback whale songs as indicators of migration routes." Marine Mammal Science 6(2): 155-160.

Clapham, P. J. and J. G. Mead (1999). "Megaptera novaeangliae." Mammalian Species 604: 1-9.

Clarke, M. R. (1996). "Cephalopods as prey. III. Cetaceans." Philosophical Transactions of the Royal Society of London 351: 1053-1065.

Cox, T., Ragen, T., Read, A., Vox, E., Baird, R., Balcomb, K., . . . Benner, L. (2006). Understanding the impacts of anthropogenic sound on beaked whales. Journal of Cetacean Research and Management, 7(3), 177-187.

Cummings, W. C. (1985). Bryde's whale *Balaenoptera edeni* Anderson, 1878. In. Handbook of Marine Mammals. S. H. Ridgway and R. Harrison. San Diego, CA, Academic Press. 3**:** 137-154.

D'Vincent, C. G., R. M. Nilson and R. E. Hanna. (1985). "Vocalization and coordinated feeding behavior of the humpback whale in southeastern Alaska." Scientific Reports of the Whales Research Institute 36: 41-47.

Dahlheim, M. E. and J. E. Heyning. (1999). Killer whale *Orcinus orca* (Linnaeus, 1758). In. Handbook of Marine Mammals. S. H. Ridgway and R. Harrison. San Diego, CA, Academic Press. 6**:** 281-322.

Dalebout, M. L., G. J. B. Ross, C. S. Baker, R. C. Anderson, P. B. Best, V. G. Cockcroft, H. L. Hinsz, V. M. Peddemors and R. L. Pitman. (2003). "Appearance, distribution and genetic distinctiveness of Longman's beaked whale, *Indopacetus pacificus*." Marine Mammal Science 19(3): 421-461.

Dalebout, M. L., J. G. Mead, C. S. Baker, A. N. Baker and A. L. van Helden. (2002). "A new species of beaked whale *Mesoplodon perrini* sp. n. (Cetacea: Ziphiidae) discovered through phylogenetic analyses of mitochondrial DNA sequences." Marine Mammal Science 18(3): 577-608.

Davis, R. W., N. Jaquet, D. Gendron, U. Markaida, G. Bazzino and W. Gilly (2007). "Diving behavior of sperm whales in relation to behavior of a major prey species, the jumbo squid, in the Gulf of California, Mexico." Marine Ecology Progress Series 333: 291-302.

Davis, R. W., W. E. Evans and B. Wursig (2000). *Cetaceans, Sea Turtles and Seabirds in the Northern Gulf of Mexico: Distribution, Abundance and Habitat Associations. Volume II: Technical report*. New Orleans, LA, U.S. Department of the Interior, Geological Survey, Biological Resources Division, and Minerals Management Service, Gulf of Mexico OCS Region**:** 346.

Davis, R. W., G. S. Fargion, N. May, T. D. Leming, M. Baumgartner, W. E. Evans, L. J. Hansen and K. Mullin (1998). "Physical habitat of cetaceans along the continental slope in the north-central and western Gulf of Mexico." Marine Mammal Science 14(3): 490-507.

Debusschere, Elisabeth, Kris Hostens, Dominique Adriaens, Bart Ampe, Dick Botteldooren, Gadrun De Boeck, Amelie De Muynck, Amit Kumar Sinha, Sofie Vandendriessche, Luc Van Hoorebeke, Magda Vincx, and Steven Degraer, 2015. Acoustic stress responses in juvenile sea bass Dicentrarchus labrax induced by offshore pile driving. Environmental Pollution 208 (2016) 747-757.

Dolar, M. L. L. (2008). Fraser's dolphin *Lagenodelphis hosei*. In. Encyclopedia of Marine Mammals. W. F. Perrin, B. Würsig and J. G. M. Thewissen. San Diego, CA, Academic Press**:** 485-487.

Donohue, M. J. and D. G. Foley. (2007). "Remote sensing reveals links among the endangered Hawaiian monk seal, marine debris and El Niño." Marine Mammal Science 23(2): 468–473.

Donahue, M. A. and W. L. Perryman. (2008). Pygmy killer whale Feresa attenuata. In. Encyclopedia of Marine Mammals. W. F. Perrin, B. Würsig and J. G. M. Thewissen. San Diego, CA, Academic Press: 938-939.

Donovan, G. P. (1991). "A review of IWC stock boundaries." Reports of the International Whaling Commission Special Issue 13: 39-68.

Dunphy-Daly, M. M., M. R. Heithaus and D. E. Claridge. (2008). "Temporal variation in dwarf sperm whale (*Kogia sima*) habitat use and group size off Great Abaco Island, Bahamas." Marine Mammal Science 24(1): 171-182.

Erbe C., A. MacGillivray, and R. Williams (2012). Mapping cumulative noise from shipping to inform marine spatial planning. *Journal of the Acoustical Society of America*, 132(5): 423-428.

Ersts, P. J. and H. C. Rosenbaum. (2003). "Habitat preference reflects social organization of humpback whales (Megaptera novaeangliae) on a wintering ground." Journal of Zoology, London 260: 337-345.

Fair, P. A., Adams, J., Mitchum, G., Hulsey, T. C., Reif, J. S., Houde, M., . . . Bossart, G. D. (2010). Contaminant blubber burdens in Atlantic bottlenose dolphins (*Tursiops truncatus*) from two southeastern US estuarine areas: Concentrations and patterns of PCBs, pesticides, PBDEs, PFCs, and PAHs. *Science of the Total Environment, 408*, 1577-1597. doi:10.1016/j.scitotenv.2009.12.021

Falcone, E., G. Schorr, A. Douglas, J. Calambokidis, E. Henderson, M. McKenna, J. Hildebrand and D. Moretti. (2009). "Sighting characteristics and photo-identification of Cuvier's beaked whales (*Ziphius cavirostris*) near San Clemente Island, California: A key area for beaked whales and the military?" Marine Biology 156: 2631-2640.

Fauquier, D. A., Kinsel, M. J., Dailey, M. D., Sutton, G. E., Stolen, M. K., Wells, R. S. & Gulland, F. M. D. (2009). Prevalence and pathology of lungworm infection in bottlenose dolphins Tursiops truncatus from southwest Florida. Diseases Of Aquatic Organisms, 88, 85-90. doi: 10.3354/dao02095.

Ferguson, M. C. (2005). *Cetacean Population Density in the Eastern Pacific Ocean: Analyzing Patterns With Predictive Spatial Models* Ph.D., University of California, San Diego.

Ferguson, M. C., J. Barlow, S. B. Reilly and T. Gerrodette. (2006b). "Predicting Cuvier's (*Ziphius cavirostris*) and *Mesoplodon* beaked whale population density from habitat characteristics in the eastern tropical Pacific Ocean." Journal of Cetacean Research and Management 7(3): 287-299.

Ferguson, M. C., J. Barlow, T. Gerrodette and P. Fiedler. (2001). Meso-scale patterns in the density and distribution of ziphiid whales in the eastern Pacific Ocean. Fourteenth Biennial Conference on the Biology of Marine Mammals, Vancouver, British Columbia.

Finneran, J. J., and A. K. Jenkins, 2012. Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis. U.S. Navy, SPAWAR Systems Center. April

Ford, J. K. B. (2008). Killer whale *Orcinus orca*. In. Encyclopedia of Marine Mammals. W. F. Perrin, B. Würsig and J. G. M. Thewissen. San Diego, CA, Academic Press**:** 650-657.

Ford, J.K.B., G.M. Ellis, P.F. Olesiuk, and K.C. Balcomb (2009). Linking killer whale survival and prey abundance: food limitation in the oceans' apex predator. Biol. Lett.

Ford, J. K. B., G. M. Ellis, D. R. Matkin, K. C. Balcomb, D. Briggs and A. B. Morton (2005). "Killer whale attacks on minke whales: Prey capture and antipredator tactics." Marine Mammal Science 21(4):603-618.

Forestell, P. H. and J. Urbán-Ramirez (2007). Movement of a Humpback Whale (*Megaptera novaeangliae*) between the Revillagigedo and Hawaiian Archipelagos within a Winter Breeding Season. LAJAM 6(1): 97-102.

Forney, K.A., E.A. Becker, D.G. Foley, J. Barlow, and E.M. Oleson. 2015. *Habitat-based models of cetacean density and distribution in the central North Pacific*. Endangered Species Research 27: 1-20.

Forney, K., R. Baird and E. Oleson. (2010). Rationale for the 2010 revision of stock boundaries for the Hawai'i insular and pelagic stocks of false killer whales, *Pseudorca crassidens*. NOAA Technical Memorandum, NOAA-TM-NMFS-SWFSC-471.

Frantzis, A., J. C. Goold, E. K. Skarsoulis, M. I. Taroudakis and V. Kandia. (2002). "Clicks from Cuvier's beaked whales, *Ziphius cavirostris* (L)." Journal of the Acoustical Society of America 112(1): 34-37.

Fulling, G. L., Thorson, P. H., Rivers, J. (2011). Distribution and Abundance Estimates for Cetaceans in the Waters off Guam and the Commonwealth of the Northern Mariana Islands. Offical Journal of the Pacific Science Association, In press Pacific Science, 1-46.

Fulling, G. L., K. D. Mullin and C. W. Hubard (2003). "Abundance and distribution of cetaceans in outer continental shelf waters of the U.S. Gulf of Mexico." Fishery Bulletin 101: 923-932.

Gallo-Reynoso, J. P. and A. L. Figueroa-Carranza (1995). "Occurrence of bottlenose whales in the waters of Isla Guadalupe, Mexico." Marine Mammal Science 11(4): 573-575.

Gannier, A. (2000). "Distribution of cetaceans off the Society Islands (French Polynesia) as obtained from dedicated surveys." Aquatic Mammals 26(2): 111-126.

Gannier, A. and E. Praca (2007). "SST fronts and the summer sperm whale distribution in the north-west Mediterranean Sea." Journal of the Marine Biological Association of the United Kingdom 87: 187-193.

Gannier, A. and K. L. West (2005). "Distribution of the rough-toothed dolphin (*Steno bredanensis*) around the Windward Islands, (French Polynesia)." Pacific Science 59: 17-24.

Geijer, C. K. A. and A. J. Read. (2013). Mitigation of marine mammal bycatch in U.S. fisheries since 1994. Biological Conservation 159:54-60.

Gilmartin, W. G. and J. Forcada (2009). Monk seals *Monachus monachus, M. tropicalis*, and *M. schauinslandi*. In. Encyclopedia of Marine Mammals. W. F. Perrin, B. Wursig and J. G. M. Thewissen, Academic Press**:** 741-744.

Goldbogen, J. A., J. Calambokidis, R. E. Shadwick, E. M. Oleson, M. A. McDonald and J. A. Hildebrand (2006). "Kinematics of foraging dives and lunge-feeding in fin whales." Journal of Experimental Biology 209: 1231-1244.

Goodman-Lowe, G. D. (1998). Diet of the Hawaiian monk seal (*Monachus schauinslandi*) from the Northwestern Hawaiian Islands during 1991-1994. In. Marine Biology. 132**:** 535-546.

Green, G. A., J. J. Brueggeman, R. A. Grotefendt, C. E. Bowlby, M. L. Bonnell and K. C. Balcomb, III. (1992). *Cetacean distribution and abundance off Oregon and Washington, 1989-1990*. Los Angeles, CA, Minerals Management Service**:** 100.

Gregr, E. J. and A. W. Trites (2001). "Predictions of critical habitat for five whale species in the waters of coastal British Columbia." Canadian Journal of Fisheries and Aquatic Sciences 58: 1265-1285.

Griffin, R. B. and N. J. Griffin (2004). "Temporal variation in Atlantic spotted dolphin (*Stenella frontalis*) and bottlenose dolphin (*Tursiops truncatus*) densities on the west Florida continental shelf." Aquatic Mammals 30(3): 380-390.

Hamer, D. J., S. J. Childerhouse and N. J. Gales (2010). Mitigating operational interactions between odontocetes and the longline fishing industry: A preliminary global review of the problem and of potential solutions. Tasmania, Australia, International Whaling Commission: 30.

Handley, C. O. (1966). A synopsis of the genus *Kogia* (pygmy sperm whales). In. Whales, Dolphins, and Porpoises. K. S. Norris, University of California Press: 62-69.

Hawaiian Islands Humpback Whale National Marine Sanctuary. (2014). Hawaiian Islands Disentanglement Network. 2013-2014 Disentanglement Season Summary. Accessed at http://hawaiihumpbackwhale.noaa.gov/res/2014_disentanglement.html. Revised May 8, 2014.

HDR. (2012). Summary Report: Compilation of Visual Survey Effort and Sightings for Marine Species Monitoring in the Hawaii Range Complex, 2005-2012. Prepared for Commander, U.S. Pacific Fleet, Pearl Harbor, Hawaii. Submitted to Naval Facilities Engineering Command Pacific (NAVFAC), EV2 Environmental Planning, Pearl Harbor, Hawaii, 96860-3134, under contract # N62470-10-D-3011, issued to HDR, Inc., San Diego, California, 92123.

Herman, L. M., Baker, C. S., Forestell, P. H. & Antinoja, R. C. (1980). Right Whale *Balaena glacialis* Sightings Near Hawaii: A Clue to the Wintering Grounds? Marine Ecology - Progress Series, 2, 271-275.

Heyning, J. E. (1989). Cuvier's beaked whale *Ziphius cavirostris* G. Cuvier, 1823. In. Handbook of Marine Mammals. S. H. Ridgway and R. Harrison. San Diego, CA, Academic Press. 4**:** 289-308.

Heyning, J. E. and J. G. Mead (2008). Cuvier's beaked whale *Ziphius cavirostris*. In. Encyclopedia of Marine Mammals. W. F. Perrin, B. Wursig and J. G. M. Thewissen, Academic Press**:** 294-295.

Hickmott, L. S. (2005). *Diving behaviour and foraging behaviour and foraging ecology of Blainville's and Cuvier's beaked whales in the Northern Bahamas*. Master of Research in Environmental Biology Master's thesis, University of St. Andrews.

Hildebrand, J. A. (2009). Anthropogenic and natural sources of ambient noise in the ocean. Marine Ecology Progress Series, vol. 395: 5-20.

Hill, M.C., A.L. Bradford, K.R. Andrews, R.W. Baird, M.H. Deakos, S.D. Johnston, D.W., Mahaffy, A.J. Milette, E.M. Oleson, J. Östman-Lind, A.A. Pack, S.H. Rickards, and S. Yin. 2011. *Abundance and movements of spinner dolphins off the main Hawaiian Islands*. Pacific Islands Fisheries Science Center Working Paper WP-11-013.

Horwood, J. (2009). Sei whale *Balaenoptera borealis*. In. Encyclopedia of Marine Mammals. W. F. Perrin, B. Wursig and J. G. M. Thewissen. San Diego, CA, Academic Press**:** 1001-1003.

Horwood, J. (1987). *The Sei Whale: Population Biology, Ecology, and Management*. New York, NY, Croom Helm**:** 375.

Houser, D. S., Finneran, J. J., Ridgway, S. H. (2010b). Research with Navy Marine Mammals Benefits Animal Care, Conservation and Biology. International Journal of Comparative Psycology, 23, 249-268.

Hui, C. A. (1985). “Undersea topography and the comparative distribution of two pelagic cetaceans.” Fishery Bulletin 83: 472-475.

Jefferson, T. A. (2009b). Rough-toothed dolphin Steno bredanensis. In W. F. Perrin, B. Wursig & J. G. M. Thewissen (Eds.), Encyclopedia of Marine Mammals (Second Edition) (pp. 990-992): Academic Press.

Jefferson, T. A. and N. B. Barros. (1997). “Peponocephala electra.” Mammalian Species 553: 1-6.

Jefferson, T. A. and S. Leatherwood. (1994). “*Lagenodelphis hosei*.” Mammalian Species 470: 1-5.

Jefferson, T. A., M. A. Webber, and R. L. Pitman. (2015). *Marine Mammals of the World: A Comprehensive Guide to their Identification*. Second Edition. London, UK, Elsevier: 608 p.

Jepson, P., Bennett, P., Deaville, R., Allchin, C. R., Baker, J. & Law, R. (2005). Relationships between polychlorinated Biphenyls and Health Status in Harbor Porpoises (Phocoena Phocoena) Stranded in the United Kingdom. Environmental Toxicology and Chemistry, 24(1), 238-248.

Johanos, T. C., A. L. Harting, T. L. Wurth, and J. D. Baker. (2015). Range-wide patterns in Hawaiian monk seal movements among islands and atolls. U.S. Department of Commerce, NOAA Technical Memorandum, NOAA-TM NMFS-PIFSC-44, 26 p. doi:10.7289/V5FT8J02

Kanda, N., M. Goto, H. Kato, M. V. McPhee and L. A. Pastene. (2007). “Population genetic structure of Bryde’s whales (Balaenoptera brydei) at the inter-oceanic and trans-equatorial levels.” Conservative Genetics 8(4): 853-864.

Kato, H. and W. F. Perrin. (2008). Bryde’s whales *Balaenoptera edeni/brydei*. In. Encyclopedia of Marine Mammals. W. F. Perrin, B. Wursig and J. G. M. Thewissen. San Diego, CA, Academic Press**:** 158-163.

Katsumata, E., K. Ohishi and T. Maruyama. (2004). “Rehabilitation of a rescued pygmy sperm whale stranded on the Pacific coast of Japan.” IEEE Journal: 488-491.

Keck, N., O. Kwiatek, F. Dhermain, F. Dupraz, H. Boulet, C. Danes, C. Laprie, A. Perrin, J. Godenir, L. Micout and G. Libeau. (2010). “Resurgence of Morbillivirus infection in Mediterranean dolphins off the French coast.” The Veterinary record 166(21): 654-655.

Kemp, N. J. (1996). Habitat loss and degradation. In The Conservation of Whales and Dolphins. M. P. Simmonds and J. Lagerquist, B. A., B. R. Mate, J. G. Ortega-Ortiz, M. Winsor, and J. Urban-Ramirez (2008). Migratory movements and surfacing rates of humpback whales (Megaptera novaeangliae) satellite tagged at Socorro Island, Mexico. Marine Mammal Science, 24(4): 815–830. D. Hutchinson. New York, NY, John Wiley & Sons**:** 476.

Kenney, R. D. and H. E. Winn. (1987). “Cetacean biomass densities near submarine canyons compared to adjacent shelf/slope areas.” Continental Shelf Research **7**: 107-114.

Kishiro, T. (1996). “Movements of marked Bryde’s whales in the western North Pacific.” Reports of the International Whaling Commission 46: 421-428.

Krahn, M. M., M. J. Ford, W. F. Perrin, P. R. Wade, R. P. Angliss, M. B. Hanson, B. L. Taylor, G. M. Ylitalo, M. E. Dahlheim, J. E. Stein and R. S. Waples (2004). *2004 Status Review of Southern Resident Killer Whales (Orcinus orca) under the Endangered Species Act*. Seattle, WA, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northwest Fisheries Science Center**:** 73.

Kruse, S., D. K. Caldwell and M. C. Caldwell (1999). Risso's dolphin *Grampus griseus* (G. Cuvier, 1812). In. Handbook of Marine Mammals. S. H. Ridgway and R. Harrison. San Diego, CA, Academic Press. 6**:**183-212.

Kuker, K. J., J. A. Thomson and U. Tscherter (2005). "Novel surface feeding tactics of minke whales, Balaenoptera acutorostrata, in the Saguenay-St. Lawrence National Marine Park." Canadian Field-Naturalist 119(2): 214-218.

Lammers, M. O. (2004). "Occurence and behavior of Hawaiian spinner dolphins (*Stenella longirostris*) along Oahu's leeward and south shores." Aquatic Mammals 30(2): 237-250.

Lammers, M. O., P. I. Fisher-Pool, W. W. L. Au, C. G. Meyer, K. B. Wong, R. E. Brainard (2011). Humpback whale Megaptera novaeangliae song reveals wintering activity in the Northwestern Hawaiian Islands. Marine Ecology Progress Series, 423: 261–268.

Leatherwood, S., W. F. Perrin, V. L. Kirby, C. L. Hubbs and M. Dahlheim (1980). "Distribution and movements of Risso's dolphin, *Grampus griseus*, in the eastern North Pacific." Fishery Bulletin 77(4): 951-963.

Leslie, M. S., A. Batibasaga, D. S. Weber, D. Olson and H. C. Rosenbaum (2005). "First record of Blainville's beaked whale *Mesoplodon densirostris* in Fiji." Pacific Conservation Biology 11(4): 302-304.

Lindstrom, U. and T. Haug (2001). "Feeding strategy and prey selectivity in common minke whales (*Balaenoptera acutorostrata*) foraging in the southern Barents Sea during early summer." Journal of Cetacean Research and Management 3(3): 239-250.

Littnan, C. (2011). *Habitat Use and Behavioral Monitoring of Hawaiian Monk Seals in Proximity to the Navy Hawaii Range Complex. Report Period: August 2010-July 2011.* Appendix M, HRC annual monitoring report for 2011, submitted to National Marine Fisheries Service.

Littnan, C., 2012. *Habitat Use and Behavioral Monitoring of Hawaiian Monk Seals in Proximity to the Navy Hawaii Range Complex*. Report Period: July 2011-June 2012.

Littnan, C. L., B. S. Stewart, P. K. Yochem and R. Braun (2007). "Survey of selected pathogens and evaluation of disease risk factors for endangered Hawaiian monk seals in the main Hawaiian Islands." EcoHealth 3: 232–244.

Lodi, L. and B. Hetzel (1999). "Rough-toothed dolphin, Steno bredanensis, feeding behaviors in Ilha Grande Bay, Brazil." Biociências 7(1): 29-42.

Lusseau, D., D. E. Bain, R. Williams and J. C. Smith (2009). "Vessel traffic disrupts the foraging behavior of southern resident killer whales *Orcinus orca*." Endangered Species Research 6: 211–221.

MacLeod, C. D. and A. D'Amico (2006). "A review of beaked whale behaviour and ecology in relation to assessing and mitigating impacts of anthropogenic noise." Journal of Cetacean Research and Management **7**(3): 211-222.

MacLeod, C. D. and G. Mitchell (2006). "Key areas for beaked whales worldwide." Journal of Cetacean Research and Management 7(3): 309-322.

MacLeod, C. D., N. Hauser and H. Peckham (2006a). "Known and inferred distributions of beaked whale species (Ziphiidae: Cetacea)." Journal of Cetacean Research and Management 7(3): 271-286.Macleod, C.D., Simmonds, M.P., and E. Murry (2006b). Abundance of fin (*Balaenoptera physalus*) and sei whales (B**.**

borealis) amid oil exploration and development off northwest Scotland. Journal of Cetacean Research and Management (3) Vol. 8, pp. 247-254.

MacLeod, C. D., N. Hauser and H. Peckham (2006a). "Known and inferred distributions of beaked whale species (Ziphiidae: Cetacea)." Journal of Cetacean Research and Management 7(3): 271-286.Macleod, C.D., Simmonds, M.P., and E. Murry (2006b). Abundance of fin (*Balaenoptera physalus*) and sei whales (B**.** *borealis*) amid oil exploration and development off northwest Scotland. Journal of Cetacean Research and Management (3) Vol. 8, pp. 247-254.

Macleod, C.D., Simmonds, M.P., and E. Murry (2006b). Abundance of fin (*Balaenoptera physalus*) and sei whales (B**.** *borealis*) amid oil exploration and development off northwest Scotland. Journal of Cetacean Research and Management (3) Vol. 8, pp. 247-254.

MacLeod, C. D., N. Hauser and H. Peckham (2004). "Diversity, relative density and structure of the cetacean community in summer months east of Great Abaco, Bahamas." Journal of the Marine Biological Association of the United Kingdom 84: 469-474.

MacLeod, C. D., N. Hauser and H. Peckham (2003). "Review of data on diets of beaked whales: evidence of niche separation and geographic segregation." Journal of the Marine Biological Association of the United Kingdom 83: 651-665.

Maldini Feinholz, D. (2003). Abundance and distribution patterns of Hawaiian odontocetes: Focus on O'ahu. Ph. D. Ph.D. dissertation, University of Hawaii.

Maldini, D., L. Mazzuca and S. Atkinson (2005). "Odontocete stranding patterns in the main Hawaiian Islands (1937-2002): How do they compare with live animal surveys?" Pacific Science 59(1): 55-67.

Marcoux, M., H. Whitehead and L. Rendell (2007). "Sperm whale feeding variations by location, year, social group and clan: Evidence from stable isotopes." Marine Ecology Progress Series 333: 309-314.

Marine Mammal Commission (2003). *Workshop on the management of Hawaiian monk seals on beaches in the main Hawaiian Islands***:** 5.

Marine Mammal Commission. (2002). Hawaiian monk seal (*Monachus schauinslandi*). Species of Special Concern, Annual Report to Congress, 2001. Bethesda, MD, Marine Mammal Commission**:** 63-76.

Marsh, H. E. (1989). "Mass Stranding of Dugongs by a Tropical Cyclone in Northern Australia." Marine Mammal Science 5(1): 78-84.

Marten, K. (2000). "Ultrasonic analysis of pygmy sperm whale (*Kogia breviceps*) and Hubbs' beaked whale (*Mesoplodon carlhubbsi*) clicks." Aquatic Mammals 26(1): 45-48.

Marten, K. and S. Psarakos (1999). "Long-term site fidelity and possible long-term associations of wild spinner dolphins (*Stenella longirostris*) seen off Oahu, Hawaii." Marine Mammal Science 15(4): 1329-1336.

Martin, S. W., C. R. Martin, B. M. Matsuyama, and E. E. Henderson, 2015. Minke whales (*Balaenoptera acutorostrata*) respond to navy training. Journal of the Acoustical Society of America 137(5), May 2015.

Martin, C. R., S. W. Martin, E .E. Henderson, T. A. Helble, R. A. Manzano-Roth, and B. M. Matsuyama. (2016). SSC Pacific FY15 annual report on PMRF Marine Mammal Monitoring.

Masaki, Y. (1976). "Biological studies on the North Pacific sei whale." Bulletin of the Far Seas Fisheries Research Laboratory 14: 1-104.

Masaki, Y. (1977). "The separation of the stock units of sei whales in the North Pacific." Reports of the International Whaling Commission (Special Issue 1): 71-79.

Matkin, C. O., Saulitis, E. L., Ellis, G. M., Olesiuk, P. & Rice, S. D. (2008). Ongoing population-level impacts on killer whales Orcinus orca following the 'Exxon Valdez' oil spill in Prince William Sound, Alaska. Marine Ecology Progress Series, 356, 269-281. doi: 10.3354/meps07273.

McAlpine, D. F. (2009). Pygmy and dwarf sperm whales *Kogia breviceps* and ***K. sima.*** In. Encyclopedia of Marine Mammals (Second Edition). W. F. Perrin, B. Wursig and J. G. M. Thewissen, Academic Press**:** 936-938.

McCracken, M.L., and K.A Forney (2010). Preliminary Assessment of Incidental Interactions with Marine Mammals in the Hawaii Longline Deep and Shallow Set Fisheries. National Marine Fisheries Service, PIFSC Working Paper WP-10-001.

McDonald, M., J. Hildebrand, S. Wiggins and D. Ross (2008). "A 50 Year comparison of ambient ocean noise near San Clemente Island: A bathymetrically complex coastal region off Southern California." Journal of the Acoustical Society of America: 1985-1992.

McSweeney, D. J., R. W. Baird and S. D. Mahaffy (2007). "Site fidelity, associations, and movements of Cuvier's (*Ziphius cavirostris*) and Blainville's (*Mesoplodon densirostris*) beaked whales off the Island of Hawaii." Marine Mammal Science 23(3): 666-687.

Mead, J. G. (1989). Beaked whales of the genus ***Mesoplodon.*** In. Handbook of Marine Mammals. S. H. Ridgway and R. Harrison. San Diego, CA, Academic Press. 4: 349-430.

Mead, J. G. and C. W. Potter (1995). "Recognizing two populations of the bottlenose dolphin (*Tursiops truncatus*) off the Atlantic Coast of North America: Morphologic and ecologic considerations." IBI Reports 5: 31-44.

Mignucci-Giannoni, A. A. (1998). "Zoogeography of cetaceans off Puerto Rico and the Virgin Islands." Caribbean Journal of Science 34(3-4): 173-190.

Miyashita, T. (1993). "Distribution and abundance of some dolphins taken in the North Pacific driftnet fisheries." International North Pacific Fisheries Commission Bulletin 53(3): 435-450.

Miyashita, T., T. Kishiro, N. Higashi, F. Sato, K. Mori and H. Kato (1996). "Winter distribution of cetaceans in the western North Pacific inferred from sighting cruises 1993-1995." Reports of the International Whaling Commission 46: 437-442.

Miyazaki, N. and W. F. Perrin (1994). Rough-toothed dolphin *Steno bredanensis* (Lesson, 1828). In Handbook of Marine Mammals. S. H. Ridgway and R. Harrison. San Diego, CA, Academic Press. 5: 1-21.

Miyazaki, N. and S. Wada (1978). "Fraser's dolphin, *Lagenodelphis hosei* in the western North Pacific." Scientific Reports of the Whales Research Institute 30: 231-244.

Mizroch, S. A., D. W. Rice, D. Zwiefelhofer, J. Waite and W. L. Perryman (2009). "Distribution and movements of fin whales in the North Pacific Ocean." Mammal Review 39: 193-227.

Mobley, J. R. (2004). *Results of Marine Mammal Surveys on U.S. Navy Underwater Ranges in Hawaii and Bahamas***:** 27.

Mobley, J. R. (2005). "Assessing responses of humpback whales to North Pacific Acoustic Laboratory (NPAL) transmissions: Results of 2001-2003 aerial surveys north of Kauai." Journal of the Acoustical Society of America 117: 1666-1773.

Mobley, J. R., Jr., L. Mazzuca, A. S. Craig, M. W. Newcomer and S. S. Spitz (2001a). "Killer whales (*Orcinus orca*) sighted west of Ni'ihau, Hawai'i." Pacific Science 55: 301-303.

Mobley, J., S. Spitz and R. Grotefendt (2001b). Abundance of Humpback Whales in Hawaiian Waters: Results of 1993-2000 Aerial Surveys, Hawaiian Islands Humpback Whale National Marine Sanctuary, Department of Land and Natural Resources, State of Hawaii: 17.

Mobley, J. R., Spitz, S., Grotefendt, R., Forstell, P., Frankel, A. & Bauer, G. (2001). *Abundance of humpback whales in Hawaiian waters: results of 1993–2000 aerial surveys*. Report to the Hawaiian Islands Humpback Whale National Marine Sanctuary (16 pp.) Hawaiian Islands Humpback Whale National Marine Sanctuary.

Mobley, J. R., Jr., S. S. Spitz, K. A. Forney, R. Grotefendt and P. H. Forestell (2000). *Distribution and Abundance of Odontocete Species in Hawaiian Waters: Preliminary Results of 1993-98 Aerial Surveys*, Southwest Fisheries Science Center**:** 26.

Mobley, J. R., Jr., G. B. Bauer and L. M. Herman (1999). "Changes over a ten-year interval in the distribution and relative abundance of humpback whales (*Megaptera novaeangliae*) wintering in Hawaiian waters." Aquatic Mammals 25: 63-72.

Mobley, J. R., Jr., M. Smultea, T. Norris and D. Weller (1996). "Fin whale sighting north of Kaua'i, Hawai'i." Pacific Science 50: 230-233.

Moon, H. B., Kannan, K., Choi, M., Yu, J., Choi, H. G., An, Y. R., . . . Kim, Z. G. (2010). Chlorinated and brominated contaminants including PCBs and PBDEs in minke whales and common dolphins from Korean coastal waters. Journal of Hazardous Materials, 179(1-3), 735-741.

Moore, J. C. (1972). "More skull characters of the beaked whale *Indopacetus pacificus* and comparative measurements of austral relatives." Fieldiana Zoology 62: 1-19.

Mussi, B., A. Miragliuolo, T. De Pippo, M. C. Gambi and D. Chiota (2004). "The submarine canyon of Cuma (southern Tyrrhenian Sea, Italy), a cetacean key area to protect." European Research on Cetaceans 15: 178-179.

National Marine Fisheries Service (NMFS). (2016). Species in the Spotlight. Priority Actions: 2016-2020. Hawaiian Monk Seal 5-Year Action Plan.

National Marine Fisheries Service (NMFS). (2014). Final Programmatic Environmental Impact Statement for Hawaiian Monk Seal Recovery Actions. March 2014.

National Marine Fisheries Service (NMFS). (2012). Endangered and Threatened Wildlife and Plants; Endangered Status for the Main Hawaiian Islands Insular False Killer Whale Distinct Population Segment. Federal Register, 77(229), 70915-70939.

National Marine Fisheries Service (NMFS). (2011c). Pacific Science Center Stranding Data. Excel file containing stranding from the Hawaiian Islands, manuscript on file.

National Marine Fisheries Service (NMFS). (2011d). Pacific Islands Region, Marine Mammal Response Network Activity Update #17.

National Marine Fisheries Service (NMFS). (2010b). Pacific Islands Regional Office. Hawaiian monk seal population and location. 2010.

National Marine Fisheries Service (NMFS). (2010c). Pacific Islands Regional Office. Hawaiian monk seal top threats. 2010.

National Marine Fisheries Service (NMFS). (2010e). Pacific Islands Region, Marine Mammal Response Network Activity Update #14 (pp. 6).

National Marine Fisheries Service (NMFS). (2009a). Taking and Importing of Marine Mammals; U.S. Navy Training in the Hawaii Range Complex; Final Rule. Federal Register, Monday, January 12, 2009, 74(7):1456-1491.

National Marine Fisheries Service (NMFS). (2008a). Pacific Islands Region, Marine Mammal Response Network Activity Update #8.

National Marine Fisheries Service (NMFS). (2007a). Pacific Islands Region, Marine Mammal Response Network Activity Update #5.

National Marine Fisheries Service (NMFS). (2007d). Recovery plan for the Hawaiian monk seal (*Monachus schauinslandi*). Silver Spring, MD, National Marine Fisheries Service**:** 165.

National Marine Fisheries Service (NMFS). (1988). "Critical habitat; Hawaiian monk seal; Endangered Species Act." Federal Register 53(102): 18988-18998.

National Marine Fisheries Service (NMFS). (1986). "Designated critical habitat; Hawaiian monk seal." Federal Register 51(83): 16047-16053.

National Oceanographic and Atmospheric Administration (NOAA) (2015). Draft Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing: Underwater Acoustic Threshold Levels for Onset of Permanent and Temporary Threshold Shifts. Revised Version for Second Public Comment Period. July 23, 2015.

National Oceanic and Atmospheric Administration (NOAA). (2012). Endangered and Threatened Wildlife and Plants; Endangered Status for the Main Hawaiian Islands Insular False Killer Whale Distinct Population Segment. Federal Register, 77(229), 70915-70939.

National Oceanic and Atmospheric Administration (NOAA) Fisheries. (2015). Hawaiian Monk Seal (*Neomonachus schauinslandi*). NOAA Pacific Islands Fisheries Science Center. Information last updated on August 21, 2015, and accessed at http://www.fisheries.noaa.gov/pr/species/mammals/seals/hawaiian-monk-seal.html. Information accessed on January 26, 2016.

National Research Council. (2003). Ocean Noise and Marine Mammals (pp. 219). Washington, DC: National Academies Press.

National Research Council. (2005). Marine mammal populations and ocean noise. Washington, DC: National Academies Press.

Natoli, A., V. M. Peddemors and A. R. Hoelzel (2004). "Population structure and speciation in the genus Tursiops based on microsatellite and mitochondrial DNA analyses." Journal of Evolutionary Biology 17: 363-375.

Nemoto, T. and A. Kawamura. (1977). "Characteristics of food habits and distribution of baleen whales with special reference to the abundance of North Pacific sei and Bryde's whales." Reports of the International Whaling Commission Special Issue 1: 80-87.

Norman, S. A., C. E. Bowlby, M. S. Brancato, J. Calambokidis, D. Duffield, P. J. Gearin, T. A. Gornall, M. E. Gosho, B. Hanson, J. Hodder, S. J. Jeffries, B. Lagerquist, D. M. Lambourn, B. Mate, B. Norberg, R. W. Osborne, J. A. Rash, S. Riemer and J. Scordino. (2004). "Cetacean strandings in Oregon and Washington between 1930 and 2002." Journal of Cetacean Research and Management 6(1): 87-99.

Norris, K. S. and T. P. Dohl (1980). "Behavior of the Hawaiian spinner dolphin, Stenella longirostris." Fishery Bulletin 77: 821-849.

Norris, T. F., M. A. Smultea, A. M. Zoidis, S. Rankin, C. Loftus, C. Oedekoven, J. L. Hayes and E. Silva (2005). *A Preliminary Acoustic-Visual Survey of Cetaceans in Deep Waters around Ni'ihau, Kaua'i, and portions of O'ahu, Hawai'i from Aboard the R/V* Dariabar. Bar Harbor, ME**:** 75.

Norris, T. F., M. McDonald and J. Barlow (1999). "Acoustic detections of singing humpback whales (*Megaptera novaeangliae*) in the eastern North Pacific during their northbound migration." Journal of the Acoustical Society of America 106(1): 506-514.

Norris, K. S., B. Wursig, R. S. Wells and M. Wursig (1994). *The Hawaiian Spinner Dolphin*. Berkeley, CA, University of California Press**:** 408.

Northridge, S. (2008). Fishing industry, effects of. In Encyclopedia of Marine Mammals. W. F. Perrin, B. Wursig and J. G. M. Thewissen. San Diego, CA, Academic Press: 443-447.

Nowacek, D., L. H. Thorne, D. Johnston and P. Tyack (2007). "Responses of cetaceans to anthropogenic noise." Mammal Review 37(2): 81-115.

Odell, D. K. and K. M. McClune (1999). False killer whale -- *Pseudorca crassidens* (Owen, 1846). In. Handbook of Marine Mammals, vol. 6: The Second Book of Dolphins and the Porpoises. S. H. Ridgway and S. R. Harrison. New York, Academic Press. 6: The second book of dolphins and the porpoises: 213-244.

Ohizumi, H. and T. Kishiro (2003). "Stomach contents of a Cuvier's beaked whale (*Ziphius cavirostris*) stranded on the central Pacific coast of Japan." Aquatic Mammals 29(1): 99-103.

Ohizumi, H., T. Matsuishi and H. Kishino (2002). "Winter sightings of humpback and Bryde's whales in tropical waters of the western and central North Pacific." Aquatic Mammals 28(1): 73-77.

Oleson, E., and M. Hill (2009). *Report to PACFLT: Data Collection and Preliminary Results from the Main Hawaiian Islands Cetacean Assessment Survey & Cetacean Monitoring Associated with Explosives Training off Oahu. 2010 Annual Range Complex Monitoring Report for Hawaii and Southern California.*

Oleson, E.M, R.W. Baird, K.K. Martien, and B.L. Taylor. 2013. *Island-associated stocks of odontocetes in the main Hawaiian Islands: A synthesis of available information to facilitate evaluation of stock structure*. Pacific Islands Fisheries Science Center Working Paper WP-13-003.

Oleson, E. M., C. H. Boggs, K. A. Forney, B. Hanson, D. R. Kobayashi, B. L. Taylor, P. Wade and G. M. Ylitalo (2010). *Status Review of Hawaiian Insular False Killer Whales (*Pseudorca crassidens*) under the Endangered Species Act*, U.S. Department of Commerce and National Oceanic and Atmospheric Administration**:** 140 + Appendices.

Olson, P. A. (2009). Pilot whales *Globicephala melas* and *G. macrorhynchus*. In Encyclopedia of Marine Mammals. W. F. Perrin, B. Würsig and J. G. M. Thewissen. San Diego, CA, Academic Press**:** 898-903.

Östman-Lind, J., A. D. Driscoll-Lind and S. H. Rickards. (2004). *Delphinid Abundance, Distribution and Habitat Use off the Western Coast of the Island of Hawaii*. La Jolla, CA, National Marine Fisheries Service.

Oswald, J. N., J. Barlow and T. F. Norris. (2003). "Acoustic identification of nine delphinid species in the eastern tropical Pacific Ocean." Marine Mammal Science 19(1): 20-37.

Panigada, S., M. Zanardelli, M. Mackenzie, C. Donovan, F. Melin and P. Hammond (2008). "Modelling habitat preferences for fin whales and striped dolphins in the Pelagos Sanctuary (Western Mediterranean Sea) with physiographic and remote sensing variables." Remote Sensing of Environment 112(8): 3400-3412.

Paniz-Mondolfi, A. E. and L. Sander-Hoffmann (2009). "Lobomycosis in inshore and estuarine dolphins." Emerging Infectious Diseases 15(4): 672-673.

Parrish, F. A., G. J. Marshall, B. Buhleier and G. A. Antonelis (2008). "Foraging interaction between monk seals and large predatory fish in the Northwestern Hawaiian Islands." Endangered Species Research 4(3): 299-308.

Parrish, F. A., M. P. Craig, T. J. Ragen, G. J. Marshall and B. M. Buhleier (2000). "Identifying diurnal foraging habitat of endangered Hawaiian monk seals using a seal-mounted video camera." Marine Mammal Science 16(2): 392-412.

Payne, P. M. and D. W. Heinemann (1993). "The distribution of pilot whales (*Globicephala* spp.) in shelf/shelf edge and slope waters of the northeastern United States, 1978-1988." Reports of the International Whaling Commission Special Issue 14: 51-68.

Perkins, J. S. and G. W. Miller (1983). "Mass stranding of *Steno bredanensis* in Belize." Biotropica 15(3): 235-236.

Perrin, W. F. (2008b). Pantropical spotted dolphin *Stenella attenuata*. In. Encyclopedia of Marine Mammals. W. F. Perrin, B. Wursig and J. G. M. Thewissen, Academic Press: 819-821.

Perrin, W. F. (2008c). Spinner dolphin *Stenella longirostris*. In. Encyclopedia of Marine Mammals. W. F. Perrin, B. Wursig and J. G. M. Thewissen, Academic Press: 1100-1103.

Perrin, W. F. (2001). "*Stenella attenuata*." Mammalian Species 683: 1-8.

Perrin, W. F. (1976). "First record of the melon-headed whale, *Peponocephala electra*, in the eastern Pacific, with a summary of world distribution." Fishery Bulletin 74(2): 457-458.

Perrin, W. F. and J. W. Gilpatrick, Jr. (1994). Spinner dolphin *Stenella longirostris* (Gray, 1828). In Handbook of Marine Mammals, Volume 5: The first book of dolphins. S. H. Ridgway and R. Harrison. San Diego, CA, Academic Press. 5: 99-128.

Perrin, W. F. and A. A. Hohn (1994). Pantropical spotted dolphin *Stenella attenuata*. In Handbook of Marine Mammals. S. H. Ridgway and R. Harrison. San Diego, CA, Academic Press. 5: 71-98.

Perrin, W.F., B. Würsig and J.G.M. Thewissen. 2009. Encyclopedia of Marine Mammals. Second Edition. Academic Press, Amsterdam.

Perrin, W. F., C. E. Wilson and F. I. Archer, II (1994a). Striped dolphin--*Stenella coeruleoalba* (Meyen, 1833). In Handbook of Marine Mammals. S. H. Ridgway and R. Harrison. San Diego, CA, Academic Press. 5: The First Book of Dolphins: 129-159.

Perrin, W. F., S. Leatherwood and A. Collet (1994b). Fraser's dolphin Lagenodelphis hosei Fraser, 1956. Handbook of Marine Mammals, Volume 5: The first book of dolphins. S. H. Ridgway and R. Harrison. San Diego, California, Academic Press: 225-240.

Perrin, W. F., P. B. Best, W. H. Dawbin, K. C. Balcomb, R. Gambell and G. J. B. Ross (1973). "Rediscovery of Fraser's dolphin *Lagenodelphis hosei*." Nature 241: 345-350.

Perry, S. L., D. P. DeMaster and G. K. Silber (1999). "The great whales: history and status of six species listed as Endangered under the U.S. Endangered Species Act of 1973." Marine Fisheries Review 61(1): 1-74.

Perryman, W. L. (2008). Melon-headed whale *Peponocephala electra*. In. Encyclopedia of Marine Mammals. W. F. Perrin, B. Wursig and J. G. M. Thewissen, Academic Press**:** 719-721.

Perryman, W. L. and T. C. Foster (1980). *Preliminary Report on Predation by Small Whales, Mainly the False Killer Whale,* Pseudorca crassidens*, on Dolphins (*Stenella spp*. and* Delphinus delphis*) in the Eastern Tropical Pacific*. La Jolla, CA, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center**:** 9.

Perryman, W. L., D. W. K. Au, S. Leatherwood and T. A. Jefferson (1994). Melon-headed whale *Peponocephala electra* Gray, 1846. Handbook of Marine Mammals, Volume 5: The first book of dolphins. S. H. Ridgway and R. Harrison, Academic Press**:** 363-386.

Pierce, G., M. Santos, C. Smeenk, A. Saveliev and A. Zuur (2007). "Historical trends in the incidence of strandings of sperm whales (*Physeter macrocephalus*) on North Sea coasts: An association with positive temperature anomalies." Fisheries Research 87(2-3): 219-228.

Pitman, R. (2008a). Indo-Pacific beaked whale *Indopacetus pacificus*. In. Encyclopedia of Marine Mammals. W. F. Perrin, B. Wursig and J. G. M. Thewissen, Academic Press**:** 600-602.

Pitman, R. L. and C. Stinchcomb (2002). "Rough-toothed dolphins (*Steno bredanensis*) as predators of mahi mahi (*Coryphaena hippurus*)." Pacific Science 56(4): 447-450.

Pitman, R. L., H. Fearnbach, R. LeDuc, J. W. Gilpatrick, Jr., J. K. B. Ford and L. T. Ballance (2007). "Killer whales preying on a blue whale calf on the Costa Rica Dome: Genetics, morphometrics, vocalisations and composition of the group." Journal of Cetacean Research and Management 9(2): 151-157.

Pitman, R. L., D. W. K. Au, M. D. Scott and J. M. Cotton (1988). *Observations of Beaked Whales (*Ziphiidae*) from the Eastern Tropical Pacific Ocean*, International Whaling Commission.

Poole, M. M. (1995). Aspects of the behavioral ecology of spinner dolphins (*Stenella longirostris*) in the nearshore waters of Mo'orea, French Polynesia Ph.D. dissertation, University of California, Santa Cruz.

Pryor, T., K. Pryor and K. S. Norris (1965). "Observations on a pygmy killer whale (*Feresa attenuata* Gray) from Hawaii." Journal of Mammalogy 46(3): 450-461.

Rankin, S. and J. Barlow (2007). "Sounds recorded in the presence of Blainville's beaked whales, *Mesoplodon densirostris*, near Hawaii (L)." Journal of the Acoustical Society of America 122(1): 42-45.

Rankin, S. and J. Barlow (2005). "Source of the North Pacific "boing" sound attributed to minke whales." Journal of the Acoustical Society of America 118: 3346-3351.

Rankin, S., T. F. Norris, M. A. Smultea, C. Oedekoven, A. M. Zoidis, E. Silva and J. Rivers (2007). "A visual sighting and acoustic detections of minke whales, Balaenoptera acutorostrata (Cetacea: Balaenopteridae), in nearshore Hawaiian waters." Pacific Science 61: 395-398.

Read, A. J. (2008). "The looming crisis: Interactions between marine mammals and fisheries." Journal of Mammalogy 89(3): 541-548.

Reeves, R., S. Leatherwood and R. Baird (2009). "Evidence of a possible decline since 1989 in false killer whales (*Pseudorca crassidens*) around the main Hawaiian Islands." Pacific Science 63: 253-261.

Reeves, R. R., W. F. Perrin, B. L. Taylor, C. S. Baker and S. L. Mesnick (2004). *Report of the Workshop on Shortcomings of Cetacean Taxonomy in Relation to Needs of Conservation and Management, April 30 - May 2,* *2004 La Jolla, California*. La Jolla, CA, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center**:** 94.

Reeves, R. R., B. S. Stewart, P. J. Clapham and J. A. Powell (2002). *National Audubon Society Guide to Marine Mammals of the World*. New York, NY, Alfred A. Knopf**:** 527.

Reilly, S. B. (1990). "Seasonal changes in distribution and habitat differences among dolphins in the eastern tropical Pacific." Marine Ecology Progress Series 66: 1-11.

Reilly, S.B., Bannister, J.L., Best, P.B., Brown, M., Brownell Jr., R.L., Butterworth, D.S., Clapham, P.J., Cooke, J., Donovan, G.P., Urbán, J. & Zerbini, A.N. (2008). *Eubalaena japonica*. In: IUCN 2012. IUCN Red List of Threatened Species. Version 2012.1. <www.iucnredlist.org>. Downloaded on 29 September 2012.

Rice, D. W. (1998). Marine mammals of the world: systematics and distribution. Society for Marine Mammalogy Special Publication. Lawrence, KS, Society for Marine Mammalogy: 231.

Rice, D. W. (1989). Sperm whale *Physeter macrocephalus* Linnaeus, 1758. In Handbook of Marine Mammals, Volume 4: River dolphins and the larger toothed whales. S. H. Ridgway and R. Harrison. San Diego, CA, Academic Press. 4: 177-234.

Ritter, F. (2002). "Behavioural observations of rough-toothed dolphins (*Steno bredanensis*) off La Gomera, Canary Islands (1995-2000), with special reference to their interactions with humans." Aquatic Mammals 28(1): 46-59.

Robertson, K. M. and S. J. Chivers (1997). "Prey occurrence in pantropical spotted dolphins, *Stenella attenuata*, from the eastern tropical Pacific." Fishery Bulletin 95(2): 334-348.

Rolland, R.M, Susan E. Parks, Kathleen E. Hunt, Manuel Castellote, Peter J. Corkeron, Douglas P. Nowacek, Samuel K. Wasser and Scott D. Kraus. (2012). Evidence that ship noise increases stress in right whales. ***Proc. R. Soc.*** *B Biological Sciences* 279, 2363-2368. doi: 10.1098/rspb.2011.2429.

Rosel, P. E. and H. Watts (2008). "Hurricane impacts on bottlenose dolphins in the northern Gulf of Mexico." Gulf of Mexico Science 25(1): 88-94.

Ross, G. J. B. (1971). "Shark attack on an ailing dolphin *Stenella coeruleoalba* (Meyen)." South African Journal of Science 67: 413-414.

Ross, G. J. B. and S. Leatherwood (1994). Pygmy killer whale Feresa attenuata Gray, 1874. Handbook of Marine Mammals, Volume 5: The first book of dolphins. S. H. Ridgway and R. Harrison, Academic Press**:** 387-404.

Rowntree, V., J. Darling, G. Silber and M. Ferrari (1980). "Rare sighting of a right whale (*Eubalaena glacialis*) in Hawaii." Canadian Journal of Zoology 58: 4.

Salden, D. R. (1989). An observation of apparent feeding by a sub-adult humpback whale off Maui, Hawaii. [Abstract]. Presented at the Eighth Biennial Conference on the Biology of Marine Mammals, Pacific Grove, CA. 7-11 December.

Salden, D., & Mickelsen, J. (1999). Rare Sighting of a North Pacific Right Whale (Eubalaena glacialis) in Hawai'i. Pacific Science, 53(4), 341-345.

Salden, D.R., Herman, L.M., Yamaguchi, M. and Sato, F. (1999) Multiple visits of individual humpback whales (*Megaptera novaeangliae*) between the Hawaiian and Japanese winter grounds. Canadian Journal of Zoology 77: 504-508.

Santos, M. B., V. Martin, et al. (2007). "Insights into the diet of beaked whales from the atypical mass strandings in the Canary Islands in September 2002." Journal of the Marine Biological Association of the United Kingdom 87: 243-251.

Schilling, M. R., I. Seipt, M. T. Weinrich, S. E. Frohock, A. E. Kuhlberg and P. J. Clapham (1992). "Behavior of individually identified sei whales *Balaenoptera borealis* during an episodic influx into the southern Gulf of Maine in 1986." Fishery Bulletin 90: 749-755.

Schmelzer, I. (2000). "Seals and seascapes: Covariation in Hawaiian monk seal subpopulations and the oceanic landscape of the Hawaiian Archipelago." Journal of Biogeography 27: 901-914.

Scott, M. D. and S. J. Chivers (1990). Distribution and herd structure of bottlenose dolphins in the eastern tropical Pacific Ocean. In. The Bottlenose Dolphin. S. Leatherwood and R. R. Reeves, Academic Press**:** 387-402.

Sears, R. and W. F. Perrin (2008). Blue whale. In. Encyclopedia of Marine Mammals. W. F. Perrin, B. Wursig and J. G. M. Thewissen. San Diego, CA, Academic Press: 120-124.

Sekiguchi, K., N. T. W. Klages and P. B. Best (1992). "Comparative analysis of the diets of smaller odontocete cetaceans along the coast of southern Africa." South African Journal of Marine Science 12: 843-861.

Shallenberger, E. W. (1981). *The Status of Hawaiian Cetaceans*. Kailua, HI, Manta Corporation: 79.

Shane, S. H. (1990). Comparison of bottlenose dolphin behavior in Texas and Florida, with a critique of methods for studying dolphin behavior. In. The Bottlenose Dolphin. S. Leatherwood and R. R. Reeves. San Diego, CA, Academic Press**:** 541-558.

Smith, B. D., G. Braulik, S. Strindberg, R. Mansur, M. A. A. Diyan and B. Ahmed (2009). "Habitat selection of freshwater-dependent cetaceans and the potential effects of declining freshwater flows and sea level rise in waterways of the Sundarbans mangrove forest, Bangladesh." Aquatic Conservation: Marine and Freshwater Ecosystems 19: 209-225.

Smultea, M. A. (1994). "Segregation by humpback whale (*Megaptera novaeangliae*) cows with a calf in coastal habitat near the island of Hawaii." Canadian Journal of Zoology 72: 805-811.

Smultea, M. A., T. A. Jefferson and A. M. Zoidis (2010). "Rare sightings of a Bryde's whale (*Balaenoptera edeni*) and sei whales (*B. borealis*) (Cetacea: Balaenopteridae) northeast of O'ahu, Hawai'i." Pacific Science 64: 449-457.

Smultea, M. A., J. L. Hopkins and A. M. Zoidis (2008b). *Marine Mammal and Sea Turtle Monitoring Survey in Support of Navy Training Exercises in the Hawai'i Range Complex November 11-17, 2007*. C. R. Organization. Oakland, CA: 62.

Smultea, M. A., J. L. Hopkins and A. M. Zoidis (2007). *Marine Mammal Visual Survey in and near the Alenuihaha Channel and the Island of Hawai'i: Monitoring in Support of Navy Training Exercises in the Hawai'i Range Complex, January 27 – February 2, 2007*. Oakland, CA**:** 63.

Southall, B., J. Calambokidis, P. Tyack, D. Moretti, A. Friedlaender, S. DeRuiter, J. Goldbogen, E. Falcone, G. Schorr, A. Douglas, A. Stimpert, J. Hildebrand, C. Kyburg, R. Carlson, T. Yack, and J. Barlow (2012). Biological and Behavioral Response Studies of Marine Mammals in Southern California, 2011 ("SOCAL-11"), Final Project Report, 8 March 2012. Manuscript on file.

Southall, B. L., Tyack, P. L., Moretti, D., Clark, C., Claridge, D. & Boyd, I. (2009). Behavioral responses of beaked whales and other cetaceans to controlled exposures of simulated sonar and other sounds, 18th Biennial Conference on the Biology of Marine Mammals. Quebec City, Quebec, Canada.

Stafford, K., D. Bohnenstiehl, M. Tolstoy, E. Chapp, D. Mellinger and S. Moore (2004). "Antarctic-type blue whale calls recorded at low latitudes in the Indian and eastern Pacific oceans." Deep-Sea Research I 51: 1337-1346.

Steiger, G., J. Calambokidis, J. Straley, L. Herman, S. Cerchio, D. Salden, J. Urban-R, J. Jacobsen, O. Ziegesar, K. Balcomb, C. Gabriele, M. Dahlheim, S. Uchida, J. Ford, P. Ladron de Guevara-P, M. Yamaguchi and J. Barlow (2008). "Geographic variation in killer whale attacks on humpback whales in the North Pacific: implications for predation pressure." Endangered Species Research 4(3): 247- 256.

Stewart, B. S., G. A. Antonelis, J. D. Baker and P. K. Yochem (2006). "Foraging biogeography of Hawaiian monk seals in the Northwestern Hawaiian Islands." Atoll Research Bulletin 543: 131–146.

Twiss, J. R., Jr. and R. R. Reeves (1999). Conservation and Managment of Marine Mammals. Washington, D.C., Smithsonian Institution Press: 471.

Tyack, P. L. (2009). "Human-generated sound and marine mammals." Physics Today: 39-44.

Tyack, P., Zimmer, W., Moretti, D., Southall, B., Claridge, D., Durban, J., . . . Boyd, I. (2011). Beaked Whales Respond to Simulated and Actual Navy Sonar. [electronic version]. PLoS ONE, 6(3), 15. 10.1371/journal.pone.0017009.

Tyne, J., K. Pollock, D. Johnston, and L. Bejder. 2013. *Abundance and survival rates of the Hawaii Island associated spinner dolphin (Stenella longirostris) stock*. PLoS ONE 9(1): e86132.

Department of the Navy. (2015). *Hawaii-Southern California Training and Testing (HSTT) - 2014 Annual Monitoring Report*. Prepared by Commander, U.S. Pacific Fleet, Pearl Harbor, Hawaii. Prepared for and submitted to National Marine Fisheries Service, Silver Spring, MD.

U.S. Department of the Navy. (2014). Commander Task Force 3rd and 7th Fleet Navy Marine Species Density Database. NAVFAC Pacific Technical Report. Naval Facilities Engineering Command Pacific, Pearl Harbor, HI.

U.S. Department of the Navy. (2011). Marine Species Monitoring for the U.S. Navy's Hawaii Range Complex and the Southern California Range Complex, 2011 Annual Report. Available at www.nmfs.noaa.gov/pr/permits/incidental.htm#applications

U.S. Department of the Navy. (2009a). Marine Species Monitoring for the U.S. Navy's Hawaii Range Complex and the Southern California Range Complex, 2009 Annual Report. Available at www.nmfs.noaa.gov/pr/permits/incidental.htm#applications.

U.S. Department of the Navy. (2006). Rim of the Pacific Exercise After Action Report: Analysis of Effectiveness of Mitigation and Monitoring Measures as Required Under the Marine Mammals Protection Act (MMPA) Incidental Harassment Authorization and the National Defense Exemption from the Requirements of the MMPA for Mid-Frequency Active Sonar Mitigation Measures**:** 60.

U.S. Navy, 2001. "Appendix D: Physical impacts of explosions on marine mammals and turtles," in *Final Environmental Impact Statement: Shock Trial of the Winston S. Churchill (DDG 81)*, edited by J. James C.Craig (Department of the Navy and U.S. Department of Commerce, NOAA, National Marine Fisheries Service), pp. 1-43.

Van Waerebeek, K., F. Felix, B. Haase, D. Palacios, D. M. Mora-Pinto and M. Munoz-Hincapie. (1998). "Inshore records of the striped dolphin, *Stenella coeruleoalba*, from the Pacific coast of South America." Reports of the International Whaling Commission 48: 525-532.

Wade, P.R. (1994). Abundance and Population Dynamics of Two Eastern Pacific Dolphins, *Stenella attenuata* and *Stenella longirostris orientalis*. (Doctoral dissertation). University of California, San Diego.

Wade, P. R. and T. Gerrodette (1993). "Estimates of cetacean abundance and distribution in the eastern tropical Pacific." Reports of the International Whaling Commission 43: 477-493.

Wade, P. R., J. M. Ver Hoef and D. P. DeMaster (2009). "Mammal-eating killer whales and their prey — trend data for pinnipeds and sea otters in the North Pacific Ocean do not support the sequential megafaunal collapse hypothesis." Marine Mammal Science 25(3): 737-747.

Wang, J. Y. and S. C. Yang. (2006). "Unusual cetacean stranding events of Taiwan in 2004 and 2005." Journal of Cetacean Research and Management 8(3): 283-292.

Wang, J. Y., S. C. Yang and H. C. Liao. (2001). "Species composition, distribution and relative abundance of cetaceans in the waters of southern Taiwan: Implications for conservation and eco-tourism." Journal of the National Parks of Taiwan 11(2): 136-158.

Waring, G. T., T. Hamazaki, D. Sheehan, G. Wood and S. Baker. (2001). "Characterization of beaked whale (Ziphiidae) and sperm whale (*Physeter macrocephalus*) summer habitat in shelf-edge and deeper waters off the northeast U.S." Marine Mammal Science **17**(4): 703-717.

Watkins, W. A., M. A. Daher, G. M. Reppucci, J. E. George, D. L. Martin, N. A. DiMarzio and D. P. Gannon (2000). "Seasonality and distribution of whale calls in the North Pacific." Oceanography 13(1): 62-67.

Weller, D. W. (2008). Predation on marine mammals. In Encyclopedia of Marine Mammals. W. F. Perrin, B. Würsig and J. G. M. Thewissen. San Diego, CA, Academic Press**:** 923-931.

Weller, D. W., B. Wursig, H. Whitehead, J. C. Norris, S. K. Lynn, R. W. Davis, N. Clauss and P. Brown. (1996). "Observations of an interaction between sperm whales and short-finned pilot whales in the Gulf of Mexico." Marine Mammal Science 12(4): 588-593.

Wells, R. S. and M. D. Scott. (2008). Common bottlenose dolphin *Tursiops truncatus*. In. Encyclopedia of Marine Mammals. W. F. Perrin, W. B. and J. G. M. Thewissen, Academic Press**:** 249-255.

Wells, R. S. and M. D. Scott. (1999). Bottlenose dolphin *Tursiops truncatus* (Montagu, 1821). In. Handbook of Marine Mammals, Volume 6: The Second Book of Dolphins and the Porpoises. S. H. Ridgway and R. Harrison. San Diego, CA, Academic Press**:** 137-182.

Wells, R. S., C. A. Manire, L. Byrd, D. R. Smith, J. G. Gannon, D. Fauqiuer and K. D. Mullin. (2009). "Movements and dive patterns of a rehabilitated Risso's dolphin, Grampus griseus, in the Gulf of Mexico and Atlantic Ocean." Marine Mammal Science 25(2): 420-429.

Werth, A. J. (2006a). "Mandibular and dental variation and the evolution of suction feeding in Odontoceti." Journal of Mammalogy 87(3): 579-588.

Werth, A. J. (2006b). "Odontocete suction feeding: Experimental analysis of water flow and head shape." Journal of Morphology 267: 1415-1428.

West, K. L., Sanchez, S., Rotstein, D., Robertson, K. M., Dennison, S., Levine, G., . . . Jensen, B. (2012). A Longman's beaked whale (*Indopacetus pacificus*) strands in Maui, Hawaii, with first case of morbillivirus in the central Pacific. Marine Mammal Science, n/a-n/a. 10.1111/j.1748-7692.2012.00616.x Retrieved from http://dx.doi.org/10.1111/j.1748-7692.2012.00616.x

West, K. L., W. A. Walker, R. W. Baird, W. White, G. Levine, E. Brown and D. Schofield. (2009). "Diet of pygmy sperm whales (*Kogia breviceps*) in the Hawiian Archipelago." Marine Mammal Science 25(4): 931-943.

Whitehead, H. (2003). *Sperm Whales: Social Evolution in the Ocean*, University of Chicago Press**:** 431.

Whitehead, H., A. Coakes, N. Jaquet and S. Lusseau. (2008). "Movements of sperm whales in the tropical Pacific." Marine Ecology Progress Series 361: 291-300.

Würsig, B. and W.J. Richardson. (2009). Noise, effects of. Pp. 765–772. In: Perrin, W.F., Würsig, B., and J.G.M. Thewissen, Eds. The Encyclopedia of Marine Mammals, Ed. 2. Academic/Elsevier Press, San Diego, Ca. 1316 pp.

Wursig, B., T. A. Jefferson and D. J. Schmidly. (2000). The Marine Mammals of the Gulf of Mexico, Texas A&M University Press**:** 232.

Yamada, T. K. (1997). "Strandings of cetacea to the coasts of the Sea of Japan - with special reference to *Mesoplodon stejnegeri*." IBI Reports 7: 9-20.0

APPENDIX A

ACOUSTIC MODELING METHODOLOGY

This page is intentionally blank.

Long Range Strike WSEP
MMPA and ESA
Acoustic Impact Modeling:
Modeling Appendix

Submitted by:

Leidos

To:

Air Force Civil Engineer Center
AFCEC/CZN

In response to tasking associated with:
Task Order CK02 under Contract W912BU-12-D-0027

Leidos Program Manager & Technical POC:

Dr. Brian Sperry

Marine Sciences R&D Division

4001 N. Fairfax Dr.

Arlington, VA 22203

Office: 703-907-2551

Fax: 703-276-3121

Email: Brian.J.Sperry@leidos.com

Table of Contents

List of Tables

List of Figures

APPENDIX A
MMPA AND ESA ACOUSTIC IMPACT MODELING

A.1 BACKGROUND AND OVERVIEW

A.1.1 Federal Regulations Affecting Marine Animals

All marine mammals are protected under the Marine Mammal Protection Act (MMPA). The MMPA prohibits, with certain exceptions, the take of marine mammals in U.S. waters and by U.S. citizens on the high seas, and the importation of marine mammals and marine mammal products into the U.S.

The Endangered Species Act of 1973 (ESA) provides for the conservation of species that are endangered or threatened throughout all or a significant portion of their range, and the conservation of their ecosystems. A "species" is considered endangered if it is in danger of extinction throughout all or a significant portion of its range. A species is considered threatened if it is likely to become an endangered species within the foreseeable future. Some marine mammals, already protected under MMPA, are also listed as either endangered or threatened under ESA, and are afforded special protections. In addition, all sea turtles are protected under the ESA.

Actions involving sound in the water may have the potential to harass marine animals in the surrounding waters. Demonstration of compliance with the MMPA and ESA, using best available science, has been assessed using criteria and thresholds accepted or negotiated, and described here.

Sections of the MMPA (16 USC 1361 et seq.) direct the Secretary of Commerce to allow, upon request, the incidental, but not intentional, taking of small numbers of marine mammals by U.S. citizens who engage in a specified activity, other than commercial fishing, within a specified geographical region. Through a specific process, if certain findings are made and regulations are issued or, if the taking is limited to harassment, notice of a proposed authorization is provided to the public for review.

Authorization for incidental takings may be granted if National Marine Fisheries Service (NMFS) finds that the taking will have no more than a negligible impact on the species or stock(s), will not have an immitigable adverse impact on the availability of the species or stock(s) for subsistence uses, and that the permissible methods of taking, and requirements pertaining to the mitigation, monitoring and reporting of such taking are set forth.

NMFS has defined negligible impact in 50 CFR 216.103 as 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 effects on annual rates of recruitment or survival.

Subsection 101(a)(5)(D) of the MMPA established an expedited process by which citizens of the United States can apply for an authorization to incidentally take small numbers of marine mammals by harassment. The National Defense Authorization Act of 2004 (NDAA) (Public Law 108-136) removed the small numbers limitation and amended the definition of "harassment" as it applies to a military readiness activity to read as follows:

> (i) *any act that injures or has the significant potential to injure a marine mammal or marine mammal stock in the wild [Level A Harassment]; or*
> (ii) *any act that disturbs or is likely to disturb a marine mammal or marine mammal stock in the wild by causing disruption of natural behavioral patterns, including, but not limited to, migration, surfacing, nursing, breeding, feeding,*

or sheltering, to a point where such behavioral patterns are abandoned or significantly altered [Level B Harassment].

The primary potential impact to marine mammals from underwater acoustics is Level A and Level B harassment, as defined by the MMPA from noise. Potential impacts to sea turtles from underwater acoustic exposure are primarily behavioral responses and impairment, with some potential for injury, and a very small potential for mortality.

A.1.2 Development of Animal Impact Criteria

A.1.2.1 Marine Mammals

For explosions of ordnance planned for use in the Long Range Strike WSEP mission area, in the absence of any mitigation or monitoring measures, there is a small chance that a marine mammal could be injured or killed when exposed to the energy generated from an explosive force. Analysis of noise impacts is based on criteria and thresholds initially presented in U.S. Navy Environmental Impact Statements for ship shock trials of the Seawolf submarine and the Winston Churchill (DDG 81), and subsequently adopted by NMFS.

Mortality

Lethal impact determinations currently incorporate species-specific thresholds that are based on the level of impact that would cause extensive lung injury from which one percent of exposed animals would not recover (Finneran and Jenkins, 2012). The threshold represents the expected onset of mortality, where 99 percent of exposed animals would be expected to survive. The lethal exposure level of blast noise, associated with the positive impulse pressure of the blast, is expressed as Pascal-seconds (Pa·s) and is determined using the Goertner (1982) modified positive impulse equation. This equation incorporates sound propagation, source/animal depths, and the mass of a newborn calf of the affected species. The Goertner equation used in the acoustic model to develop mortality impact analysis, is as follows:

$$I_M(M,D) = 91.4M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/2}$$

$I_M(M,D)$	mortality threshold, expressed in terms of acoustic impulse (Pa·s)
M	Animal mass (Table D-1)
D	Water depth (m)

Level A Harassment

Non-lethal injurious impacts (Level A Harassment) are defined in those documents as onset of slight lung injury, gastro-intestinal (GI) tract damage, and permanent (auditory) threshold shift (PTS).

The criteria for onset of slight lung injury were established using partial impulse because the impulse of an underwater blast wave was the parameter that governed damage during a study using mammals, not peak pressure or energy (Yelverton, 1981). Goertner (1982) determined a way to calculate impulse values for injury at greater depths, known as the Goertner "modified" impulse pressure. Those values are valid only near the surface because as hydrostatic pressure increases with depth, organs like the lung, filled with air, compress. Therefore the "modified" impulse pressure thresholds vary from the shallow depth starting point as a function of depth.

The shallow depth starting points for calculation of the "modified" impulse pressures are mass-dependent values derived from empirical data for underwater blast injury (Yelverton, 1981). During the calculations, the lowest impulse and body mass for which slight, and then extensive, lung injury found during a previous study (Yelverton et al, 1973) were used to determine the positive impulse that may cause lung injury. The Goertner model is sensitive to mammal weight such that smaller masses have lower thresholds for positive impulse so injury and harassment will be predicted at greater distances from the source for them. The equation used for determination of slight lung injury is:

$$I_S(M,D) = 39.1M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/2},$$

where M is animal mass (kg), D is animal depth (m), and the units of I_s are Pa-s. Following Finneran and Jenkins (2012), the representative mass for each species is taken to be that of an average newborn calf or pup for that species.

The criterion for slight injury to the GI tract was found to be a limit on peak pressure and independent of the animal's size (Goertner, 1982). A threshold of 103 psi (237 dB re 1 μPa) is used for all marine mammals. This level at which slight contusions to the GI tract were reported from small charge tests (Richmond *et al.,* 1973).

Two thresholds are used for PTS, one based on sound exposure level (SEL) and the other on the sound pressure level (SPL) of an underwater blast. Thresholds follow the approach of Southall et al. (2007). The threshold producing either the largest Zone of Influence (ZOI) or higher exposure levels is then used as the more protective of the dual thresholds. In most cases, the weighted total energy flux density (EFD) is more conservative that the largest EFD in any single 1/3-octave band used in earlier models. Type II weighting functions are applied for each cetacean functional hearing group and Type I weighting functions are applied for phocids such that the PTS thresholds are as follows:

<u>Low-frequency (LF) Cetaceans</u>

- SEL (Type II weighted): 187 decibels referenced to 1 microPascal-squared – seconds (dB re 1 $\mu Pa^2 \cdot s$)
- Peak SPL (unweighted): 230 decibels referenced to 1 microPascal (dB re 1 μPa)

<u>Mid-frequency (MF) Cetaceans</u>

- SEL (Type II weighted): 187 dB re 1 $\mu Pa^2 \cdot s$
- Peak SPL (unweighted): 230 dB re 1 μPa

<u>High-frequency (HF) Cetaceans</u>

- SEL (Type II weighted): 161 dB re 1 $\mu Pa^2 \cdot s$
- Peak SPL (unweighted): 201 dB re 1 μPa

<u>Phocids (In-Water)</u>

- SEL (Type I weighted) of 192 dB re 1 $\mu Pa^2 \cdot s$
- Peak SPL (unweighted) of 218 dB re 1 μPa

<u>Level B Harassment</u>

Level B (non-injurious) Harassment includes temporary (auditory) threshold shift (TTS), a slight, recoverable loss of hearing sensitivity. One criterion used for TTS, the total Type II weighted EFD of the signal, is a threshold of 172 dB re 1 μPa^2-s for LF and MF cetaceans. A second criterion, a maximum allowable peak pressure of 23 psi (224 dB re 1 μPa), has recently been established by NMFS to provide a more conservative range for TTS when the explosive or animal approaches the sea surface, in which case explosive energy is reduced, but the peak pressure is not. NMFS applies the more conservative of these two. For species where no data exist, TTS thresholds are based on the most closely related species for which data are available. The TTS thresholds for each functional hearing group are as follows:

<u>LF Cetaceans</u>
- SEL (Type-II weighted) of 172 dB re 1 μPa^2·s
- Peak SPL (unweighted) of 224 dB re 1 μPa

<u>MF Cetaceans</u>
- SEL (Type II weighted) of 172 dB re 1 μPa^2·s
- Peak SPL (unweighted) of 224 dB re 1 μPa

<u>HF Cetaceans</u>
- SEL (Type II weighted) of 146 dB re 1 μPa^2·s
- Peak SPL (unweighted) of 195 dB re 1 μPa

<u>Phocids (In-Water)</u>
- SEL (Type I weighted) of 177 dB re 1 μPa^2·s
- Peak SPL (unweighted) of 212 dB re 1 μPa

<u>Level B Behavioral Harassment</u>

For multiple successive explosions, the acoustic criterion for non-TTS behavioral disturbance is used to account for behavioral effects significant enough to be judged as harassment, but occurring at lower sound energy levels than those that may cause TTS. The threshold for behavioral disturbance is set 5 dB below the Type II weighted total EFD-based TTS threshold, or 167 dB re 1 μPa^2-s. This is based on observations of behavioral reactions in captive dolphins and belugas occurring at exposure levels approximately 5 dB below those causing TTS after exposure to pure tones (Schlundt et al., 2000). The behavioral impacts thresholds for all functional hearing groups of marine mammals exposed to multiple, successive detonations are:

<u>LF Cetaceans</u>
- SEL (Type II weighted) of 167 dB re 1 μPa^2·s

<u>MF Cetaceans</u>
- SEL (Type II weighted) of 167 dB re 1 μPa^2·s

<u>HF Cetaceans</u>
- SEL (Type II weighted) of 141 dB re 1 μPa^2·s

<u>Phocids (In-Water)</u>
- SEL (Type I weighted) of 172 dB re 1 μPa^2·s

Table A-1 summarizes the current threshold levels for marine mammals used to analyze explosives identified for use in the Long Range Strike WSEP mission area. The mammal species of interest for Long Range Strike WSEP are spread across four functional hearing groups, three for cetaceans – low frequency (LF), mid frequency (MF) and high frequency (HF) – and one for in-water Phocids.

Table A-1. Explosives Threshold Levels for Marine Mammals

<table>
<tr><th rowspan="2">Functional Hearing Group</th><th rowspan="2">Mortality*</th><th colspan="3">Level A Harassment</th><th colspan="2">Level B Harassment</th></tr>
<tr><th>Slight Lung Injury*</th><th>GI Tract Injury</th><th>PTS</th><th>TTS</th><th>Behavioral</th></tr>
<tr><td rowspan="2">LF Cetaceans</td><td rowspan="8">$91.4M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/2}$</td><td rowspan="8">$39.1M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/2}$</td><td rowspan="2">Unweighted SPL: 237 dB re 1 μPa</td><td>Weighted SEL: 187 dB re 1 $\mu Pa^2 \cdot s$</td><td>Weighted SEL: 172 dB re 1 $\mu Pa^2 \cdot s$</td><td rowspan="2">Weighted SEL: 167 dB re 1 $\mu Pa^2 \cdot s$</td></tr>
<tr><td>Unweighted SPL: 230 dB re 1 μPa</td><td>Unweighted SPL: 224 dB re 1 μPa (23 psi PP)</td></tr>
<tr><td rowspan="2">MF Cetaceans</td><td rowspan="2">Unweighted SPL: 237 dB re 1 μPa</td><td>Weighted SEL: 187 dB re 1 $\mu Pa^2 \cdot s$</td><td>Weighted SEL: 172 dB re 1 $\mu Pa^2 \cdot s$</td><td rowspan="2">Weighted SEL: 167 dB re 1 $\mu Pa^2 \cdot s$</td></tr>
<tr><td>Unweighted SPL: 230 dB re 1 μPa</td><td>Unweighted SPL: 224 dB re 1 μPa (23 psi PP)</td></tr>
<tr><td rowspan="2">HF Cetaceans</td><td rowspan="2">Unweighted SPL: 237 dB re 1 μPa</td><td>Weighted SEL: 161 dB re 1 $\mu Pa^2 \cdot s$</td><td>Weighted SEL: 146 dB re 1 $\mu Pa^2 \cdot s$</td><td rowspan="2">Weighted SEL: 141 dB re 1 $\mu Pa^2 \cdot s$</td></tr>
<tr><td>Unweighted SPL: 201 dB re 1 μPa</td><td>Unweighted SPL: 195 dB re 1 μPa (1 psi PP)</td></tr>
<tr><td rowspan="2">Phocids (in water)</td><td rowspan="2">Unweighted SPL: 237 dB re 1 μPa</td><td>Weighted SEL: 192 dB re 1 $\mu Pa^2 \cdot s$</td><td>Weighted SEL: 177 dB re 1 $\mu Pa^2 \cdot s$</td><td rowspan="2">Weighted SEL: 172 dB re 1 $\mu Pa^2 \cdot s$</td></tr>
<tr><td>Unweighted SPL: 218 dB re 1 μPa</td><td>Unweighted SPL: 212 dB re 1 μPa (6 psi PP)</td></tr>
</table>

M = Animal mass based on species (kilograms); *D* = Water depth (meters); dB re 1 μPa = decibels referenced to 1 microPascal; dB re 1 $\mu Pa^2 \cdot s$ = decibels reference to 1 microPascal-squared – seconds; GI = gastrointestinal; PTS = permanent threshold shift; SEL = sound exposure level; ; TTS = temporary threshold shift; SPL = sound pressure level ; PP = peak pressure
*Expressed in terms of acoustic impulse (Pascal – seconds [Pa·s])

A.1.2.2 Sea Turtles

The weapons impact zone will be located in an area that is inhabited by species listed as threatened or endangered under the ESA (16 USC §§ 1531-1543), including sea turtles. Operation of sound sources, that is, transmission of acoustic signals in the water column, could potentially cause harm or harassment to listed species.

Until recently, there were no acoustic energy or pressure impact thresholds defined specifically for ESA-listed sea turtles, and in the absence of such information the thresholds used for marine mammal analysis were typically applied. However, NMFS has recently undertaken a more detailed investigation of the effects of underwater detonations on turtles and provided the following summary of potential behavioral responses at various peak dB levels (Table A-2).

Table A-2. Range of Sea Turtle Behavioral Responses at Multiple Underwater Noise Levels

dB Level (Peak) Range	Response Category	Number of Animals Potentially Affected
110 – 160	Discountable effects; minor response possible, but within the range of normal behaviors.	Very few
>160 – 200	Some swimming and diving response, becoming stronger and more frequent at higher dB levels.	Few at 160 dB; most at 200 dB
>200 – 220	Strong avoidance response.	Some to all at 220 dB
>220	Intolerable.	All individuals

dB = decibel

Although there has been recent effort to address turtle-specific thresholds, there are currently no experimental or modeling data sufficient to support development of physiological thresholds. However, NMFS has recently endorsed sea turtle criteria and thresholds for impulsive sources (including detonations) to be used in impact analysis. In some cases, turtle-specific data are not available and marine mammal criteria are therefore used. Similar to marine mammal analysis, criteria and thresholds are provided for mortality (extensive lung injury), non-lethal injury (slight lung or GI tract injury), onset of PTS and TTS, and behavioral effects (Finneran and Jenkins, 2012).

Table A-3. Criteria and Thresholds Used for Sea Turtle Exposure Impulsive Impact Analysis

Impulsive Sound Exposure Impact	Threshold Value
Onset Mortality (1% mortality based on extensive lung injury)*	$91.4M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/2}$
Onset Slight Lung Injury*	$39.1M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/2}$
Onset Slight Gastrointestinal Tract Injury	237 dB re 1 µPa SPL (104 psi)
Onset Permanent Threshold Shift	187 dB re 1 µPa^2-s SEL (T^2)
	230 dB re 1 µPa Peak SPL
Onset Temporary Threshold Shift	172 dB re 1 µPa^2-s SEL (T^2)
	224 dB re 1 µPa Peak SPL
Behavioral Effects	175 dB re 1 µPa unweighted RMS

D = depth of animal (meters); dB = decibel; dB re 1 µPa = decibels referenced to 1 micropascal; dB re 1 µPa^2·s = decibels referenced to 1 micropascal-squared second; M = animal mass based on species (kilograms); RMS = root mean square; SEL = sound exposure level; SPL = sound pressure level; T = turtle auditory weighting
*Expressed in terms of acoustic impulse (pascal seconds [Pa-s])

A.2 EXPLOSIVE ACOUSTIC SOURCES

A.2.1 Acoustic Characteristics of Explosive Sources

The acoustic sources to be deployed during Long Range Strike WSEP missions are categorized as broadband explosives. Broadband explosives produce significant acoustic energy across several frequency decades of bandwidth. Propagation loss is sufficiently sensitive to frequency as to require model estimates at several frequencies over such a wide band.

Explosives are impulsive sources that produce a shock wave that dictates additional pressure-related metrics (peak pressure and positive impulse). Detailed descriptions of the sources in the Long Range Strike WSEP mission area are provided in this subsection.

Explosives detonated underwater introduce loud, impulsive, broadband sounds into the marine environment. Three source parameters influence the effect of an explosive: the weight of the explosive material, the type of explosive material, and the detonation depth. The net explosive weight (or NEW) accounts for the first two parameters. The NEW of an explosive is the weight of TNT required to produce an equivalent explosive power.

A.2.2 Animal Harassment Effects of Explosive Sources

The harassments expected to result from these sources are computed on a per event basis, where an event lasts for 24 hours and takes into account multiple explosives that would detonate within that time period.

Within that 24-hour time period it is assumed that the animal population remains constant, or in other words, animals exposed to sounds at the beginning of the 24-hour period would also be exposed to any sounds occurring at the end of the period. A new animal population is assumed for each consecutive 24-hour period. In some cases this can be a more conservative approach than assuming each detonation, or burst of detonations, is received by a new population of animals. It is important to note that only energy metrics are affected by the accumulation of energy over a 24-hour period. Pressure metrics (e.g., peak pressure and positive impulse) do not accumulate. Rather, a maximum is taken over all of the detonations specified within the 24-hour period. A more detailed description of pressure and energy considerations resulting from munition bursts is provided in Section A.2.3 below.

Explosives are modeled as detonating at depths ranging from the water surface to 10 feet below the surface, as provided by Government-Furnished Information. Impacts from above surface detonations were considered negligible and not modeled.

For sources that are detonated at shallow depths, it is frequently the case that the explosion may breach the surface with some of the acoustic energy escaping the water column. We model surface detonations as occurring one foot below the water surface. The source levels have not been adjusted for possible venting nor does the subsequent analysis attempt to take this into account.

A.2.3 Zone of Influence: Per-Detonation Versus Net Explosive Weight Combination

It may useful to consider why and when it is appropriate to treat rounds within a burst as separate events, rather than combining the NEW of all rounds and treating it as a single, larger event. The basic information necessary to address this issue is provided below, where pressure-based metrics are considered separately from energy-level metrics.

Peak Pressure and Positive Impulse

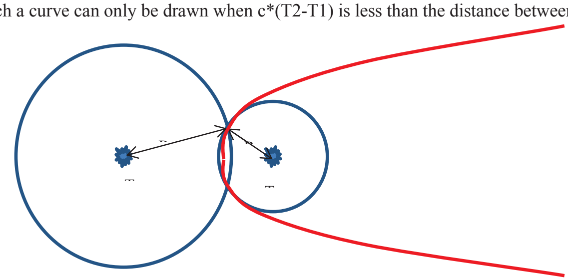
Peak pressures add if two (or more) impulses reach the same point at the same time. Since explosive rounds go off at different times and locations, this will only be true for a small set of points. This problem is mathematically the same as the passive sonar problem of localizing a sound source based on the time difference of arrival (TDOA) of a signal reaching two receivers (R1 and R2). The red curve in the figure (half of a hyperbola) represents the set of all points where:

R1 – R2 = c*(T2 – T1), for

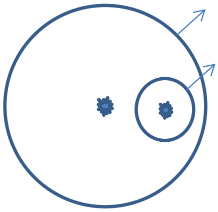
c = the speed of sound in water, and

T1 and T2 being the detonation times of the two rounds:

Such a curve can only be drawn when c*(T2-T1) is less than the distance between the two explosions. If,



for instance, 30 rounds/second are fired (and the difference in impact time is assumed to be roughly the distance in firing time), then the peak impact pressure from the first round will have traveled 1,500 meters/second * 1/30 second = 50 meters. If the second round hits less than 50 meters from the first round, the impact wave from the second round will never catch the impact wave from the first.



In the first case (loose grouping), the pressures will only add along a curve with very narrow width and negligible volume. The pressure on this curve is less than twice the pressure of the closest round, as it will be the pressure at R2 and at (R2+c*dT). In the second case (tight grouping), the pressures will never add.

If this logic is extended to a many-shot burst, the logic becomes even more persuasive. For the impulse peak from a third shot to interact with the peaks from the first two using the 30 rounds/second assumption, it would have to impact the water more than 100 meters away from the impact of the first round and more than 50 meters away from the impact of the second round. Even in that case, there would be at most two places in the ocean where the curve from the 1st and 3rd impacts would meet the curve from 2nd and 3rd explosions (and the travel distances would have to be 50 meters longer for one and 100 meters longer for the other). In summary:

- There would be 0 to 4 directions where a curve (a hyperbola approaches an asymptotic line far from the source) of negligible thickness, and volume would have less than two times the pressure from the closest source
- There would be 0 to 2 very small points with no extent in range or bearing where one would see less than three times the pressure from the closest source
- In every other part of the ZOI, the impulse from each round would be received separately by any animal present

For the 4th round and any subsequent round, another curve could be added, if it was far enough away from the previous shots so that their peak had not already passed the impact point. However, this new curve would intersect with the previous 2 curves at a different location than where the first two curves intersected. No matter how many rounds are fired, there would not be any point in the ocean where more than 3 peaks arrive at the same time. These points would have almost no volumetric extent and required range increases from the closest source of N*dt*c, where N is the difference in shot number and dt is the time between shots.

If the rate of fire is increased, there is a decrease in the additional required separation in order to have any coherent increase in pressure or positive impulse. However, the end result is that almost all of the ocean experiences only one pressure peak at a time.

If the rounds are far enough apart in space and close enough in time, there will be curves where sequential rounds add coherently; however,

- They will not occupy any significant volume, and

- They will be less than a factor of 2 above the pressure or positive impulse of the nearest source.

Contrast this with the alternative assumption that pressures from separate rounds be added. This models the event as if all rounds went of exactly at the same place and exactly at the same time. That is the only way that travelling pressure peaks from separate rounds would go through space together and add pressures at all points. This is not realistic and would over-estimate pressure and positive impulse metrics by a factor equal to the number of rounds in the burst, which could be 10 or 20 dB in pressure levels.

Energy Metrics

Energy metrics accumulate the integral of the power density of each explosion over the duration of the impulse. Thus, even though the peaks from separate explosions arrive at different times, the energy from all of their arrivals will be added. If you fire a number of rounds close together in a burst (N_{burst}), the energy from all of the rounds will add and the sound exposure level will be 10*log10(N_{burst}) higher than if a single shot had been fired. The area affected, A_{burst}, would be larger than the area affected by a single shot (A_1), because additional transmission loss would be needed to reduce the larger energy level to a given threshold.

The alternative assumption is that each round sees a fresh population and the area affected by N single bullets is $N*A_1$. The single-shot assumption is more conservative as long as $A_{burst} < N*A_1$.

A.3 ENVIRONMENTAL CHARACTERIZATION

A.3.1 Important Environmental Parameters for Estimating Animal Harassment

Propagation loss ultimately determines the extent of the ZOI for a particular source activity. In turn, propagation loss as a function of range depends on a number of environmental parameters including:

- Water depth;
- Sound speed variability throughout the water column;
- Bottom geo-acoustic properties; and
- Surface roughness, as determined by wind speed.

Due to the importance that propagation loss plays in Anti-Submarine Warfare, the Navy has, over the last four to five decades, invested heavily in measuring and modeling these environmental parameters. The result of this effort is the following collection of global databases containing these environmental parameters, which are accepted as standards for Navy modeling efforts. Table A-4 contains the version of the databases used in the modeling for this report.

Table A-4. Navy Standard Databases Used in Modeling

Parameter	Database	Version
Water Depth	Digital Bathymetry Data Base Variable Resolution	DBDBV 6.0
Ocean Sediment	Re-packed Bottom Sediment Type	BST 2.0
Wind Speed	Surface Marine Gridded Climatology Database	SMGC 2.0
Temperature/Salinity Profiles	Generalized Digital Environment Model	GDEM 3.0

The sound speed profile directs the sound propagation in the water column. The spatial variability of the sound speed field is generally small over operating areas of typical size. The presence of a strong oceanographic front is a noteworthy exception to this rule. To a lesser extent, variability in the depth and strength of a surface duct can be of some importance. If the sound speed minimum occurs within the water column, more sound energy can travel further without suffering as much loss (ducted propagation). But if the sound speed minimum occurs at the surface or bottom, the propagating sound interacts more with these boundaries and may become attenuated more quickly. In the mid-latitudes, seasonal variation often provides the most significant variation in the sound speed field. For this reason, both summer and winter profiles are modeled to demonstrate the extent of the difference.

Losses of propagating sound energy occur at the boundaries. The water-sediment boundary defined by the bathymetry can vary by a large amount. In a deep water environment, the interaction with the bottom may matter very little. In a shallow water environment the opposite is true and the properties of the sediment become very important. The sound propagates through the sediment, as well as being reflected by the interface. Soft (low density) sediment behaves more like water for lower frequencies and the sound has relatively more transmission and relatively less reflection than a hard (high density) bottom or thin sediment.

The roughness of the boundary at the water surface depends on the wind speed. Average wind speed can vary seasonally, but could also be the result of local weather. A rough surface scatters the sound energy and increases the transmission loss. Boundary losses affect higher frequency sound energy much more than lower frequencies.

A.3.2 Characterizing the Acoustic Marine Environment

The environment for modeling impact value is characterized by a frequency-dependent bottom definition, range-dependent bathymetry and sound velocity profiles (SVP), and seasonally varying wind speeds and SVPs. The bathymetry database is on a grid of variable resolution.

The SVP database has a fixed spatial resolution storing temperature and salinity as a function of time and location. The low frequency bottom loss is characterized by standard definition of geo-acoustic parameters for the given sediment type for the area. The high frequency bottom loss class is fixed to match expected loss for the sediment type. The area of interest can be characterized by the appropriate sound speed profiles, set of low frequency bottom loss parameters, high frequency bottom loss class, and HFEVA very-high frequency sediment type for modeled frequencies in excess of 10 kiloHertz (kHz).

Generally seasonal variation is sampled by looking at summer and winter cases that tend to capture extremes in both the environmental variability as well as animal populations. Calculations were made for both seasons even though events are expected to be at the end of the summer season.

Impact volumes in the operating area are then computed using propagation loss estimates and the explosives model derived for the representative environment.

A.3.3 Description of the BSURE Training Range Area Environment

The Long Range Strike mission area is located to the northwest of the Hawaiian island of Kauai, in the northern part of the BSURE tracking range. The bottom is characterized as clay according to the Bottom Sediments Type Database. Environmental values were extracted from unclassified Navy standard databases in a radius of 75 kilometers around the center point at

N 22° 50.0' W 160° 00'

The Navy standard database for bathymetry has a resolution of 0.05 minutes in the Pacific Ocean; see Figure A-1. Mean and median depths from DBDBV in the extracted area are 4,351 and 4,550 meters, respectively. Minimum and maximum depths are 1,135 and 4,848 meters, respectively.

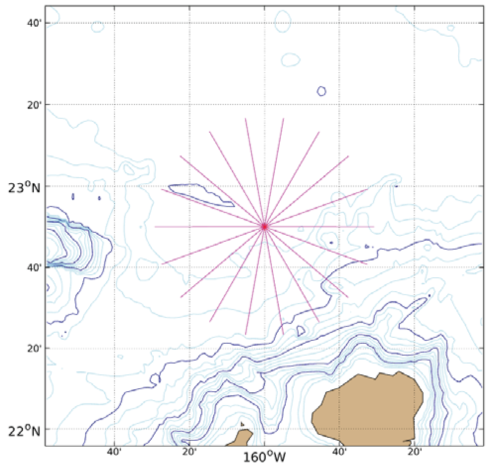


Figure A-1. Bathymetry (in 250-meter contours) for the BSURE Range and Long Range Strike WSEP mission area.

The seasonal variability in wind speed was modeled as 7.7 knots in the summer and 7.1 knots in the winter.

Example input of range-dependent bathymetry is depicted in Figure A-2 for the due-north bearing.

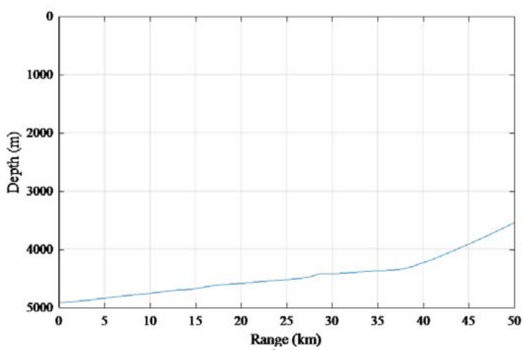


Figure A-2. Bathymetry along 150° radial to the SW from center point

A.4 MODELING IMPACT ON MARINE ANIMALS

Many underwater actions include the potential to injure or harass marine animals in the neighboring waters through noise emissions. The number of animals exposed to potential harassment in any such action is dictated by the propagation field and the characteristics of the noise source.

Estimating the number of animals that may be injured or otherwise harassed in a particular environment entails the following steps.

- For the relevant environmental acoustic parameters, transmission loss (TL) estimates are computed, sampling the water column over the appropriate depth and range intervals. TL calculations are also made over disjoint one-third octave bands for a wide range of frequencies with dependence in range, depth, and azimuth for bathymetry and sound speed. TL computations were sampled with 40 degree spacing in azimuth.
- The Type II weighted total accumulated energy within the waters where the source detonates is sampled over a volumetric grid. At each grid point, the received energy from each source emission is modeled as the effective energy source level reduced by the appropriate propagation loss from the location of the source at the time of the emission to that grid point and summed. For the peak pressure or positive impulse, the appropriate metric is similarly modeled for each emission. The maximum value of that metric over all frequencies and emissions, is stored at each grid point.
- The impact volume for a given threshold is estimated by summing the incremental volumes represented by each grid point sampled in range and depth for which the appropriate metric exceeds that threshold, and accumulated over all modeled bearings. Histograms representing impact volumes as a function of (possibly depth-dependent) thresholds, are stored in a spreadsheet for dynamic changes of thresholds.
- Finally, the number of harassments is estimated as the inner-product of the animal density depth profile and the impact volume and scaled by user-specifiable surface animal densities.

This section describes in detail the process of computing impact volumes.

A.4.1 Calculating Transmission Loss

Transmission loss (TL) was pre-computed for both seasons for thirty non-overlapping frequency bands. The 30 bands had one-third octave spacing around center frequencies from 50 Hertz (Hz) to approximately 40.637 kHz. In the previous report, TL was computed at only seven frequencies. The broadband nature of the sources has been well covered in this report. The TL was modeled using the Navy Standard GRAB V3 propagation loss model (Keenan, 2000) with CASS v4.3. GRAB is well suited to modeling transmission losses over the wide frequency band of interest.

The TL results were interpolated onto a variable range grid with logarithmic spacing. The increased spatial resolution near the source provided greater fidelity for estimates.

The TL was calculated from the source depth to an array of output depths. The output depths were the mid-points of depth intervals matching GDEM's depth sampling. For water depths from surface to 10 meter depth, the depth interval was 2 meters. Between 10 meters and 100 meters water depth, the depth interval was 5 meters. For waters greater than 100 meters, the depth interval was 10 meters. For the BSURE area environment, there were forty-five depth bins spanning 0 to 1000 meters. The output depths represent possible locations of the animals and are used with the animal depth distribution to better estimate animal impact. The depth grid is used to make the surface image interference correction and to capture the depth-dependence of the positive impulse threshold.

A.4.2 Computing Impact Areas

This section and the next provide a detailed description of the approach taken to compute impact areas for explosives. The impact area associated with a particular activity is defined as the area of water in which some acoustic metric exceeds a specified threshold. The product of this impact area and animal density yields the expected value of the number of animals exposed to that acoustic metric at a level that exceeds the threshold. The acoustic metric can either be an energy term (weighted or un-weighted energy flux density, either in a limited frequency band or across the full band) or a pressure term (such as peak pressure or positive impulse). The thresholds associated with each of these metrics define the levels at which half of the animals exposed will experience some degree of harassment (ranging from behavioral change to mortality).

Impact area is particularly relevant when trying to estimate the effect of repeated source emissions separated in either time or space. Impact range, which is defined as the maximum range at which a particular threshold is exceeded either for a single source emission or accumulation of source emissions over a 24-hour period, defines the range to which marine mammal activity is monitored in order to meet mitigation requirements. Based on the latest guidance, this impact range is also used to provide conservative two-dimensional calculations of the exposure estimates by simply by multiplying the impact area by the animal density and the total number of events proposed each year. Refer to Section A.5.1 below. This two-dimensional, maximum-range approach conservatively assumes all ranges and depths, out to the maximum range, are above threshold. In deep water environments with near-surface sources, this is a particularly conservative approach as it does not consider shadow zones where sound levels are greatly diminished due to vertical gradients in the speed of sound within the water column.

The effective energy source level is modeled directly for the sources to be used at the BT-9 target area. The energy source level is comparable to the model used for other explosives (Arons (1954), Weston (1960), McGrath (1971), Urick (1983), Christian and Gaspin (1974)). The energy source level over a one-third octave band with a center frequency of *f* for a source with a net explosive weight of *w* pounds is given by:

$$\mathrm{ESL} = 10 \log_{10} (0.26\, f) + 10 \log_{10} (2\, p_{max}^{2} / [1/\theta^{2} + 4\, \pi^{2} f^{2}]) + 197 \ \mathrm{dB}$$

where the peak pressure for the shock wave at 1 meter is defined as

$$p_{max} = 21600\, (w^{1/3} / 3.28)^{1.13} \ \mathrm{psi} \qquad \text{(B-1)}$$

and the time constant is defined as:

$$\theta = [(0.058)\, (w^{1/3})\, (3.28 / w^{1/3})^{0.22}] / 1000 \ \mathrm{sec} \qquad \text{(B-2)}$$

For each explosive source, the amount of acoustic energy injected into the water column is calculated, conservatively assuming that all explosive energy is converted into acoustic energy. The propagation loss for each frequency, expressed as a pressure term, modulates the sound energy found at each along the range (logarithmic spacing). If a threshold is exceeded at a point, the impact volume of that annular sector is added to the total impact volume. The impact area is calculated as an area of a circle with the radius equal to the maximum range across all depth bins and azimuths for each threshold and criteria.

A.4.3 Effects of Metrics on Impact Areas

The impact of explosive sources on marine wildlife is measured by three different metrics, each with its own thresholds. The energy metric, the peak pressure metric, and the "modified" positive impulse metric are discussed in this section. The energy metric, using the Type II weighted total energy, is accumulated after the explosive detonation. The other two metrics, peak pressure and positive impulse, are not accumulated but rather the maximum levels are taken.

Energy Metric

The energy flux density is sampled at several frequencies in one-third-octave bands. The total weighted energy flux at each range/depth combination is obtained by summing the product of the Type II frequency weighting function, $W_{II}(f)$, and the energy flux density at each frequency. The type II weighting function in dB is given by:

$$W_{II}(f) = maximum\big(G_1(f), G_{12}(f)\big), \text{ where}$$

$$G_1(f) = K_1 + 20log_{10}\left[\frac{b_1^2 f^2}{(a_1^2+f^2)(b_1^2+f^2)}\right], \text{ and}$$

$$G_2(f) = K_2 + 20log_{10}\left[\frac{b_2^2 f^2}{(a_2^2+f^2)(b_2^2+f^2)}\right].$$

The component lower cutoff frequencies, a_1 and a_2, upper cutoff frequencies, b_1 and b_2, and gains, K_1 and K_2, are a function of the functional hearing group. Parameters used for cetaceans are given in Table A-5.

Table A-5. Type II Weighting Parameters used for Cetaceans

Functional Hearing Group	K_1(dB)	a_1(Hz)	b_1(Hz)	K_2(dB)	a_2(Hz)	b_2(Hz)
LF cetaceans	-16.5	7	22,000	0.9	674	12,130
MF cetaceans	-16.5	150	160,000	1.4	7,829	95,520
HF cetaceans	-19.4	200	180,000	1.4	9,480	108,820

Note that because the weightings are in dB, we will actually weight each frequency's EFD by $10^{(W_{II}(f)/10)}$, sum the EFDs over frequency and then convert the weighted total energy to back to dB, with level = 10 $\log_{10}$(total weighted EFD).

Phocids and sea turtles use a simpler, Type I, weighting function to represent their hearing sensitivities. The weighting function is the same as that given above for G_1, with K_1 set to zero and a_1 and b_1 given below in Table A-6.

Table A-6. Type I Weighting Parameters for Phocids and Sea Turtles

Functional Hearing Group	a(Hz)	b(Hz)
Phocids (In-Water)	75	75,000
Sea Turtles	75	2,000

Peak Pressure Metric

The peak pressure metric is a simple, straightforward calculation at each range/animal depth combination. First, the transmission pressure ratio, modified by the source level in a one-third-octave band, is summed across frequency. This averaged transmission ratio is normalized by the total broadband source level. Peak pressure at that range/animal depth combination is then simply the product of:

- The square root of the normalized transmission ratio of the peak arrival,
- The peak pressure at a range of 1 meter (given by equation B-1), and
- The similitude correction (given by $r^{-0.13}$, where r is the slant range).

If the peak pressure for a given grid point is greater than the specified threshold, then the incremental volume for the grid point is added to the impact volume for that depth layer.

"Modified" Positive Impulse Metric

The modeling of positive impulse follows the work of Goertner (Goertner, 1982). The Goertner model defines a "partial" impulse as

$$I = \int_0^{T_{min}} p(t)dt \, ,$$

where $p(t)$ is the pressure wave from the explosive as a function of time t, defined so that $p(t) = 0$ for $t < 0$. This similitude pressure wave is modeled as

$$p(t) = p_{max} \, e^{-t/\theta}$$

where p_{max} is the peak pressure at 1 meter (see, equation B-1), and θ is the time constant defined in equation A-2.

The upper limit of the "partial" impulse integral is

$$T_{min} = \min \{T_{cut}, T_{osc}\}$$

where T_{cut} is the time to cutoff and T_{osc} is a function of the animal lung oscillation period. When the upper limit is T_{cut}, the integral is the definition of positive impulse. When the upper limit is defined by T_{osc}, the integral is smaller than the positive impulse and thus is just a "partial" impulse. Switching the integral limit from T_{cut} to T_{osc} accounts for the diminished impact of the positive impulse upon the animals lungs that compress with increasing depth and leads to what is sometimes call a "modified" positive impulse metric.

The time to cutoff is modeled as the difference in travel time between the direct path and the surface-reflected path in an isovelocity environment. At a range of r, the time to cutoff for a source depth z_s and an animal depth z_a is

$$T_{cut} = 1/c \; \{ [r^2 + (z_a + z_s)^2]^{1/2} - [r^2 + (z_a - z_s)^2]^{1/2} \}$$

where c is the speed of sound.

The animal lung oscillation period is a function of animal mass M and depth z_a and is modeled as

$$T_{osc} = 1.17 \, M^{1/3} \, (1 + z_a/33)^{-5/6}$$

where M is the animal mass (in kg) and z_a is the animal depth (in feet).

The modified positive impulse threshold is unique among the various injury and harassment metrics in that it is a function of depth and the animal weight. So instead of the user specifying the threshold, it is computed as $K\,(M)^{1/3}\,(1 + z_a/33)^{1/2}$. The coefficient K depends upon the level of exposure. For the onset of slight lung injury, K is 39.1; for the onset of extensive lung hemorrhaging (1% mortality), K is 91.4.

Although the thresholds are a function of depth and animal weight, sometimes they are summarized as their value at the sea surface for a typical dolphin calf (with an average mass of 12.2 kg). For the onset of slight lung injury, the threshold at the surface is approximately 13 psi-msec; for the onset of extensive lung hemorrhaging (1% mortality), the threshold at the surface is approximately 31 psi-msec. Note that for our calculations we use species-dependent masses.

As with peak pressure, the "modified" positive impulse at each grid point is compared to the derived threshold. If the impulse is greater than that threshold, then the incremental volume for the grid point is added to the impact volume for that depth layer.

A.5 ESTIMATING ANIMAL HARASSMENT

A.5.1 "Two-Dimensional" Harassment Estimates

If one does not have confidence in the depth-distribution of animals within the water column, then a more conservative approach to estimating harassment is to compute only a two-dimensional impact. In this approach, the impact volume is essentially a cylinder extending from the surface to the seafloor, centered at the sound source and with a radius set equal to the maximum range, R_{max}, across all depths and azimuths at which the particular metric level is still above threshold. The number of animals impacted is computed simply by multiplying the area of a circle with radius R_{max}, by the original animal density given in animals per square kilometer. Impacts computed in this manner will always exceed or equal impacts based on depth-dependent animal distributions.

A.6 REFERENCES

Arons, A. B., 1954. "Underwater Explosion Shock Wave Parameters at Large Distances from the Charge," *J. Acoust. Soc. Am*. 26, 343.

Bartberger, C. L., 1965. "Lecture Notes on Underwater Acoustics," NADC Report NADC=WR-6509, Naval Air Development Center Technical Report, Johnsville, PA, 17 May (AD 468 869) (UNCLASSIFIED).

Christian, E. A. and J. B. Gaspin, 1974. Swimmer Safe Standoffs from Underwater Explosions," NSAP Project PHP-11-73, Naval Ordnance Laboratory, Report NOLX-89, 1 July (UNCLASSIFIED).

Department of the Navy, 1998. "Final Environmental Impact Statement, Shock Testing the SEAWOLF Submarine," U.S. Department of the Navy, Southern Division, Naval Facilities Engineering Command, North Charleston, SC, 637 p.

Department of the Navy, 2001. "Final Environmental Impact Statement, Shock Trial of the WINSTON S. CHURCHILL (DDG 81)," U.S. Department of the Navy, NAVSEA, 597 p.

DeRuiter, S. L., and K. L. Doukara, 2012. Loggerhead turtles dive in response to airgun sound exposure. *Endangered Species Research*, Volume 16:55-63. January 18, 2012.

Finneran, J. J., R. Dear, D. A. Carder, and S. H. Ridgway, 2002. Temporary shift in masked hearing thresholds in odontocetes after exposure to single underwater impulses from a seismic watergun. *Journal of the Acoustical Society of America*. 111:2929-2940.

Finneran, J. J., and C. E. Schlundt, 2004. Effects of intense pure tones on the behavior of trained odontocetes. Space and Naval Warfare Systems Center, San Diego, Technical Document. September.

Finneran, J. J., D. A. Carder, C.E. Schlundt and S.H. Ridgway. 2005. Temporary threshold shift in bottlenose dolphins (Tursiops truncatus) exposed to mid-frequency tones. *Journal of Acoustical Society of America*. 118:2696-2705.

Finneran, J. J., and A. K. Jenkins, 2012. Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis. U.S. Navy, SPAWAR Systems Center. April 2012.

Goertner, J. F., 1982. "Prediction of Underwater Explosion Safe Ranges for Sea Mammals," NSWC TR 82-188, Naval Surface Weapons Center, Dahlgren, VA.

Keenan, R. E., D. Brown, E. McCarthy, H. Weinberg, and F. Aidala, 2000. “Software Design Description for the Comprehensive Acoustic System Simulation (CASS Version 3.0) with the Gaussian Ray Bundle Model (GRAB Version 2.0)”, NUWC-NPT Technical Document 11,231, Naval Undersea Warfare Center Division, Newport, RI, 1 June (UNCLASSIFIED).

Ketten, D. R., 1998. Marine mammal auditory systems: A summary of audiometric and anatomical data and its implications for underwater acoustic impacts. NOAA-TM-NMFS-SWFSC-256, Department of Commerce.

Kryter, K. D. W. D. Ward, J. D. Miller, and D. H. Eldredge, 1966. Hazardous exposure to intermittent and steady-state noise. *Journal of the Acoustical Society of America*. 48:513-523.

McCauley, R. D., J. Fewtrell, A. J. Duncan, C. Jenner, M.-N. Jenner, J. D. Penrose, R. I. T. Prince, A. Adhitya, J. Murdoch, and K. McCabe, 2000. *Marine seismic surveys: analysis and propagation of air-gun signals; and effects of air-gun exposure on humpback whales, sea turtles, fishes and squid*. CMST 163, Report R99-15, prepared for the Australian Petroleum Production Exploration Association from the Centre for Marine Science and Technology, Curtin University, Perth, Western Australia.

McGrath, J. R., 1971. “Scaling Laws for Underwater Exploding Wires,” *J. Acoust. Soc. Am*., 50, 1030-1033 (UNCLASSIFIED).

Miller, J. D., 1974. Effects of noise on people. *Journal of the Acoustical Society of America*. 56:729–764.

Nachtigall, P. E., J. L. Pawloski, and W. W. L. Au, 2003. Temporary threshold shift and recovery following noise exposure in the Atlantic bottlenose dolphin (Tursiops truncatus). *Journal of the Acoustical Society of America*, 113:3425-3429.

NOAA, 2015. “DRAFT Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing,” Revised version for Second Public Comment Period, 180 p.

Richmond, D. R., J. T. Yelverton, and E. R. Fletcher, 1973. “Far-field underwater-blast injuries produced by small charges,” DNA 3081T. Lovelace Foundation for Medical Education and Research, Defense Nuclear Agency: Washington, D.C.

Schlundt, C. E., J. J. Finneran, D. A. Carder, and S. H. Ridgway, 2000. Temporary shift in masked hearing thresholds of bottlenose dolphins, Tursiops truncatus, nd white whales, Delphinapterous leucas, after exposure to intense tones. *Journal of the Acoustical Society of America*. 107:3496-3508.

Southall, B. L., Bowles, A. E., Ellison, W. T., Finneran, J. J., Gentry, R. L., Greene, C. R., Jr., Kastak, D., Ketten, D. R., Miller, J. H., Nachtigall, P. E., Richardson, W. J., Thomas, J. A., and Tyack, P. L., 2007. “Marine mammal noise exposure criteria: initial scientific recommendations,” *Aquatic Mammals*, 33, 411-521.

Urick, R. J., 1983. Principles of Underwater Sound for Engineers, McGraw-Hill, NY (first edition: 1967, second edition: 1975, third edition: 1983) (UNCLASSIFIED).

Ward, W. D., 1997. Effects of high-intensity sound. In Encyclopedia of Acoustics, ed. M.J. Crocker, 1497-1507. New York: Wiley.

Weston, D. E., 1960. “Underwater Explosions as Acoustic Sources,” *Proc. Phys. Soc*., 76, 233 (UNCLASSIFIED).

Yelverton, J. T., 1981. Underwater Explosion Damage Risk Criteria for Fish, Birds, and Mammals, Manuscript, presented at 102nd Meeting of the Acoustical Society of America, Miami Beach, FL, December, 1982. 32pp.

APPENDIX B

MARINE MAMMALS DEPTH DISTRIBUTIONS

This page is intentionally blank.

MARINE MAMMALS DEPTH DISTRIBUTIONS USED IN ACOUSTIC MODELING

Source: Watwood, S. L., and D. M. Buonantony, 2012. Dive Distribution and Group Size Parameters for Marine Species Occurring in Navy Training and Testing Areas in the North Atlantic and North Pacific Oceans. NUWC-NPT Technical Document12,085. 12 March 2012.

Table B-1. Marine Mammals Depth Distributions Used in Acoustic Modeling

Species	Depth Category (m = meters)	Percentage of Time at Depth
Humpback whale	0 - 10 m	39.55
	10 - 20 m	26.51%
	20 - 30 m	11.66%
	30 - 40 m	4.25%
	40 - 50 m	3.04%
	50 - 60 m	2.47%
	60 - 70 m	2.14%
	70 - 80 m	1.66%
	80 - 90 m	1.97%
	90 - 100 m	1.55%
	100 - 110 m	1.39%
	110 - 120 m	1.31%
	120 - 130 m	0.92%
	130 - 140 m	0.72%
	140 - 150 m	0.20%
	150 - 160 m	0.23%
	160 - 170 m	0.15%
	170 - 180 m	0.09%
Blue whale	0 - 15 m	43.078%
	15 - 30 m	29.621%
	30 - 45 m	9.376%
	45 - 60 m	2.334%
	60 - 75 m	2.342%
	75 - 90 m	2.341%
	90 - 105 m	2.264%
	105 - 120 m	2.094%
	120 - 135 m	1.859%
	135 - 150 m	1.528%
	150 - 165 m	1.187%
	165 - 180 m	0.819%
	180 - 195 m	0.532%
	195 - 210 m	0.312%
	210 - 225 m	0.172%
	225 - 240 m	0.084%
	240 - 255 m	0.035%
	255 - 270 m	0.013%
	270 - 285 m	0.005%
	285 - 300 m	0.002%
	300 - 315 m	0.001%
Fin whale	0 - 15 m	46.460%

Species	Depth Category (m = meters)	Percentage of Time at Depth
	15 - 30 m	10.738%
	30 - 45 m	9.105%
	45 - 60 m	4.033%
	60 - 75 m	2.684%
	75 - 90 m	2.466%
	90 - 105 m	2.231%
	105 - 120 m	2.148%
	120 - 135 m	1.947%
	135 - 150 m	1.762%
	150 - 165 m	1.633%
	165 - 180 m	1.592%
	180 - 195 m	1.712%
	195 - 210 m	2.107%
	210 - 225 m	2.663%
	225 - 240 m	2.834%
	240 - 255 m	2.217%
	255 - 270 m	1.125%
	270 - 285 m	0.361%
	285 - 300 m	0.081%
	300 - 315 m	0.011%
	315 - 330 m	0.001%
Sei whale and Bryde's whale	0 - 40 m	84.50%
	40 - 292 m	15.30%
Minke whale	0 - 25 m	79.70%
	25 - 65 m	20.30%
Sperm whale	0 - 50 m	30.689%
	50 - 100 m	3.220%
	100 - 150 m	3.372%
	150 - 200 m	3.587%
	200 - 250 m	3.757%
	250 - 300 m	3.893%
	300 - 350 m	4.057%
	350 - 400 m	4.434%
	400 - 450 m	4.668%
	450 - 500 m	5.167%
	500- 550 m	4.750%
	550 - 600 m	4.024%
	600 - 650 m	3.537%
	650 - 700 m	3.112%
	700 - 750 m	2.786%
	750 - 800 m	2.461%
	800 - 850 m	2.149%
	850 - 900 m	1.836%
	900 - 950 m	1.563%
	950 - 1000 m	1.316%
	100 - 1050 m	1.098%
	1050 - 1100 m	0.892%

Species	Depth Category (m = meters)	Percentage of Time at Depth
	1100 - 1150 m	0.712%
	1150 - 1200 m	0.581%
	1200 - 1250 m	0.472%
	1250 - 1300 m	0.382%
	1300 - 1350 m	0.306%
	1350 - 1400 m	0.248%
	1400 - 1450 m	0.194%
	1450 - 1500 m	0.161%
	1500 - 1550 m	0.128%
	1550 - 1600 m	0.110%
	1600 - 1650 m	0.086%
	1650 - 1700 m	0.069%
	1700 - 1750 m	0.051%
	1570 - 1800 m	0.039%
	1800 - 1850 m	0.028%
	1850 - 1900 m	0.019%
	1900 - 1950 m	0.013%
	1950 - 2000 m	0.009%
	2000 - 2050 m	0.006%
	2050 - 2100 m	0.004%
	2100 - 2150 m	0.003%
	2150 - 2200 m	0.002%
	2200 - 2250 m	0.002%
	2250 - 2300 m	0.002%
	2300 - 2350 m	0.001%
	2350 - 2400 m	0.001%
Pygmy sperm whale and Dwarf sperm whale	0 - 17 m	74.40%
	17 - 35 m	5.20%
	35 - 53 m	2.20%
	53 - 101 m	3.80%
	101 - 149 m	2.80%
	149 - 197 m	1.80%
	197 - 299 m	3.40%
	299 - 401 m	2.60%
	401 - 599 m	2.90%
	599 - 797 m	0.90%
Killer whale	0 - 5 m	24%
	5 - 10 m	3.50%
	10 - 15 m	2.50%
	15 - 20 m	4.20%
	20 - 25 m	8%
	25 - 30 m	12%
	30 - 35 m	11%
	35 - 40 m	8.50%
	40 - 45 m	10.90%
	45 - 50 m	8.50%
	50 - 55 m	5%

Species	Depth Category (m = meters)	Percentage of Time at Depth
	55 - 60 m	1.50%
	60 - 65 m	0.40%
False killer whale, Pygmy killer whale, and Melon-headed whale	0 - 1 m	24.7500%
	1 - 2 m	13.5000%
	2 - 10 m	16.5000%
	10 - 50 m	43.5000%
	50 - 100 m	1.1875%
	100 - 150 m	0.1375%
	150 - 600 m	0.4250%
Short-finned pilot whale and Fraser's dolphin	0 - 17 m	74.40%
	17 - 35 m	5.20%
	35 - 53 m	2.20%
	53 - 101 m	3.80%
	101 - 149 m	2.80%
	149 - 197 m	1.80%
	197 - 299 m	3.40%
	299 - 401 m	2.60%
	401 - 599 m	2.90%
	599 - 797 m	0.90%
Bottlenose dolphin	0 - 5 m	74.21%
	5 - 10 m	17.04%
	10 - 15 m	3.09%
	15 - 20 m	1.41%
	20 - 25 m	1.87%
	25 - 30 m	1.59%
	30 - 35 m	0.66%
	35 - 40 m	0.12%
	40 - 45 m	0.01%
Pantropical spotted dolphin, Striped dolphin, and Spinner dolphin	0 - 2 m	20.40%
	2 - 4 m	10.70%
	4 - 6 m	8.60%
	6 - 8 m	9.00%
	8 - 10 m	9.50%
	10 - 20 m	21.30%
	20 - 30 m	8.80%
	30 - 40 m	3.80%
	40 - 50 m	2.50%
	50 - 60 m	1.90%
	60 - 70 m	1.10%
	70 - 80 m	0.60%
	80 - 90 m	0.60%
	90 - 100 m	0.40%
	100 - 110 m	0.40%
	110 - 120 m	0.30%
	120 - 130 m	0.10%
	130 - 140 m	0.10%
	140 - 150 m	0.10%

Species	Depth Category (m = meters)	Percentage of Time at Depth
	150 - 160 m	0.10%
	160 - 170 m	0.10%
Rough-toothed dolphin	0 - 10 m	77.99%
	10 - 25 m	16.24%
	25 - 50 m	3.81%
	50 - 75 m	0.93%
	75 - 100 m	0.29%
	100 - 150 m	0.11%
	150 - 200 m	0.01%
	200 - 300 m	0.01%
Risso's dolphin	0 - 1 m	24.7500%
	1 - 2 m	13.5000%
	2 - 10 m	16.5000%
	10 - 50 m	43.5000%
	50 - 100 m	1.1875%
	100 - 150 m	0.1375%
	150 - 600 m	0.4250%
Cuvier's beaked whale	0 - 50 m	49.76%
	50 - 100 m	6.38%
	100 - 150 m	5.91%
	150 - 200 m	5.03%
	200 - 250 m	3.92%
	250 - 300 m	2.95%
	300 - 350 m	2.16%
	350 - 400 m	1.63%
	400 - 450 m	1.41%
	450 - 500 m	1.36%
	500- 550 m	1.35%
	550 - 600 m	1.28%
	600 - 650 m	1.35%
	650 - 700 m	1.41%
	700 - 750 m	1.43%
	750 - 800 m	1.33%
	800 - 850 m	1.29%
	850 - 900 m	1.28%
	900 - 950 m	1.25%
	950 - 1000 m	1.13%
	100 - 1050 m	1.07%
	1050 - 1100 m	0.93%
	1100 - 1150 m	0.80%
	1150 - 1200 m	0.74%
	1200 - 1250 m	0.61%
	1250 - 1300 m	0.49%
	1300 - 1350 m	0.41%
	1350 - 1400 m	0.29%
	1400 - 1450 m	0.21%
	1450 - 1500 m	0.22%

Species	Depth Category (m = meters)	Percentage of Time at Depth
	1500 - 1550 m	0.18%
	1550 - 1600 m	0.15%
	1600 - 1650 m	0.09%
	1650 - 1700 m	0.07%
	1700 - 1750 m	0.05%
	1570 - 1800 m	0.03%
	1800 - 1850 m	0.01%
	1850 - 1900 m	0.01%
Blaineville's beaked whale and Longman's beaked whale	0 - 20 m	43.447%
	20 - 40 m	8.743%
	40 - 60 m	7.116%
	60 - 80 m	5.665%
	80 - 100 m	4.134%
	100 - 120 m	2.793%
	120 - 140 m	1.740%
	140 - 160 m	1.127%
	160 - 180 m	0.772%
	180 - 200 m	0.597%
	200 - 220 m	0.500%
	220 - 240 m	0.470%
	240 - 260 m	0.460%
	260 - 280 m	0.455%
	280 - 300 m	0.454%
	300 - 320 m	0.454%
	320 - 340 m	0.456%
	340 - 360 m	0.458%
	360 - 380 m	0.458%
	380 - 400 m	0.460%
	400 - 420 m	0.461%
	420 - 440 m	0.465%
	440 - 460 m	0.478%
	460 - 480 m	0.492%
	480 - 500 m	0.505%
	500 - 520 m	0.520%
	520 - 540 m	0.528%
	540 - 560 m	0.553%
	560 - 580 m	0.576%
	580 - 600 m	0.589%
	600 - 620 m	0.605%
	620 - 640 m	0.642%
	640 - 660 m	0.697%
	660 - 680 m	0.715%
	680 - 700 m	0.708%
	700 - 720 m	0.694%
	720 - 740 m	0.727%
	740 - 760 m	0.739%
	760 - 780 m	0.741%

Species	Depth Category (m = meters)	Percentage of Time at Depth
	780 - 800 m	0.758%
	800 - 820 m	0.781%
	820 - 840 m	0.775%
	840 - 860 m	0.694%
	860 - 880 m	0.624%
	880 - 900 m	0.601%
	900 - 920 m	0.566%
	920 - 940 m	0.512%
	940 - 960 m	0.444%
	960 - 980 m	0.384%
	980 - 1000 m	0.330%
	1000 - 1020 m	0.285%
	1020 - 1040 m	0.228%
	1040 - 1060 m	0.182%
	1060 - 1080 m	0.146%
	1080 - 1100 m	0.110%
	1100 - 1120 m	0.078%
	1120 - 1140 m	0.057%
	1140 - 1160 m	0.048%
	1160 - 1180 m	0.050%
	1180 - 1200 m	0.045%
	1200 - 1220 m	0.030%
	1220 - 1240 m	0.015%
	1240 - 1260 m	0.004%
	1260 - 1280 m	0.004%
	1280 - 1300 m	0.001%
	1300 - 1320 m	0.001%
	1320 - 1340 m	0.001%
	1340 - 1360 m	0.001%
Hawaiian monk seal	0 - 4 m	33.00%
	4 - 20 m	34.70%
	20 - 40 m	13.20%
	40 - 60 m	5.50%
	60 - 80 m	3.60%
	70 - 100 m	2.10%
	100 - 120 m	2.50%
	120 - 140 m	2.00%
	140 - 160 m	0.80%
	160 - 180 m	0.70%
	180 - 200 m	0.30%
	200 - 250 m	0.40%
	250 - 350 m	0.90%
	350 - 500 m	0.60%

This page is intentionally blank.

IHA for 2016 Missions (signed September 27, 2016)

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Silver Spring, MD 20910

Commander, US Air Force 86 Fighter Weapons Squadron
1001 Nomad Way, Bldg 1310
Suite 210
Eglin AFB, FL 32542

Dear Commander, US Air Force, 86 Fighter Weapons Squadron:

Enclosed is an Incidental Harassment Authorization (IHA) issued to the US Air Force 86 Fighter Weapons Squadron, under the authority of section 101(a)(5)(D) of the Marine Mammal Protection Act (16 U.S.C. 1361 *et seq.*), to harass marine mammals, by Level A and Level B harassment, incidental to the Long Range Strike Weapons System Evaluation Program in the Barking Sands Underwater Range Expansion area of the Pacific Missile Range Facility from October 1, 2016 through November 30, 2016.

You are required to comply with the conditions contained in the IHA. In addition, you must submit reports to the National Marine Fisheries Service's (NMFS) Office of Protected Resources within 90 days of its completion. The IHA requires aerial surveys for marine mammals by qualified individuals before and after mission activities and reporting of marine mammal observations, including species, numbers, and behavioral modifications potentially resulting from this activity.

If you have any questions concerning the IHA or its requirements, please contact Laura McCue, Office of Protected Resources, NMFS, at 301-427-8496.

Sincerely,

Donna S Wieting SEP 27 2016

Donna S. Wieting
Director, Office of Protected Resources

Enclosures

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Silver Spring, MD 20910

Incidental Harassment Authorization

The United States Air Force 86 Fighter Weapons Squadron (86 FWS) is hereby authorized under section 101(a)(5)(D) of the Marine Mammal Protection Act (16 U.S.C. 1371(a)(5)(D)) to harass marine mammals incidental to conducting the Long Range Strike Weapons System Evaluation Program (LRS WSEP) in the Barking Sands Underwater Range Expansion (BSURE) of the Pacific Missile Range Facility (PMRF), Kauai, Hawaii, contingent upon the following conditions:

1. This Authorization is valid from October 1, 2016 through November 30, 2017.

2. This Authorization is valid only for activities associated with the LRS WSEP operations utilizing munitions identified in the Attachment.

3. The incidental taking, by Level A and Level B harassment, is limited to: dwarf sperm whale (*Kogia sima*), pygmy sperm whale (*Kogia breviceps*), Fraser's dolphin (*Lagenodelphis hosei*), minke whale (*Balaenoptera acutorostrata*), and humpback whale (*Megaptera novaeangliae*) as specified in Table 1 of this notice.

4. Mission activities may only occur during daylight hours.

5. The taking by serious injury or death of the species listed in condition 3 or any taking of any other species of marine mammal is prohibited and may result in the modification, suspension or revocation of this Authorization.

6. Mitigation

The holder of this Authorization is required to implement the following mitigation measures:

- If marine mammals are detected during pre-mission surveys, all activities shall be delayed until the marine mammals are determined to have left the area or 30 minutes have passed without redetection of the animal.

7. Monitoring

The holder of this Authorization will track their use of the PMRF BSURE area for the LRS WSEP missions and marine mammal observations, through the use of mission reporting forms.

Aerial surveys: Pre- and post- mission surveys shall be conducted. Pre-mission surveys would begin approximately one hour prior to detonation. Post-detonation monitoring surveys will commence once the mission has ended and as soon as personnel declare the mission area safe.

The required monitoring area shall be approximately 2 nm (3,704 m) from the target area radius around the impact point, with surveys flown in a star pattern. Aerial surveys shall be conducted at an altitude of approximately 200 feet. If adverse weather conditions preclude the ability for aircraft to safely operate, missions must either be delayed until the weather clears or cancelled for the day. The observers shall be provided with the GPS location of the impact area. Once the aircraft reaches the impact area, pre-mission surveys shall last for 30 minutes. The aircraft shall fly the survey pattern multiple times.

8. Reporting

The holder of this Authorization is required to:

(a) Submit a draft report on all monitoring conducted under the IHA within 90 days of the completion of marine mammal monitoring, or 60 days prior to the issuance of any subsequent IHA for projects at PMRF, whichever comes first. A final report shall be prepared and submitted within 30 days following resolution of comments on the draft report from NMFS. This report must include:

1. Date and time of each LRS WSEP mission;
2. A complete description of the pre-exercise and post-exercise activities related to mitigating and monitoring the effects of LRS WSEP missions on marine mammal populations; and
3. Results of the monitoring program, including numbers by species/stock of any marine mammals noted injured or killed as a result of the LRS WSEP mission and number of marine mammals (by species if possible) that may have been harassed due to presence within the zone of influence.

The draft report will be subject to review and comment by the National Marine Fisheries Service (NMFS). Any recommendations made by the NMFS must be addressed in the final report prior to acceptance by the NMFS. The draft report will be considered the final report for this activity under this Authorization if the NMFS has not provided comments and recommendations within 90 days of receipt of the draft report.

(b) Reporting injured or dead marine mammals:

i. In the unanticipated event that the specified activity clearly causes the take of a marine mammal in a manner prohibited by this IHA, such as an injury for species not authorized (Level A harassment), serious injury, or mortality, 86 FWS shall immediately cease the specified activities and report the incident to the Office of Protected Resources, NMFS, 301-427-8496, and the Pacific Islands Regional Stranding Coordinator, NMFS, 808-354-2956. The report must include the following information:

A. Time and date of the incident;

B. Description of the incident;

C. Environmental conditions (*e.g.*, wind speed and direction, Beaufort sea state, cloud cover, and visibility);

D. Description of all marine mammal observations in the 24 hours preceding the incident;

E. Species identification or description of the animal(s) involved;

F. Fate of the animal(s); and

G. Photographs or video footage of the animal(s).

Activities shall not resume until NMFS is able to review the circumstances of the prohibited take. NMFS will work with 86 FWS to determine what measures are necessary to minimize the likelihood of further prohibited take and ensure MMPA compliance. 86 FWS may not resume their activities until notified by NMFS.

ii. In the event that 86 FWS discovers an injured or dead marine mammal, and the lead observer determines that the cause of the injury or death is unknown and the death is relatively recent (*e.g.*, in less than a moderate state of decomposition), 86 FWS shall immediately report the incident to the Office of Protected Resources, NMFS, and the Pacific Islands Regional Stranding Coordinator, NMFS.

The report must include the same information identified in 6(b)(i) of this IHA. Activities may continue while NMFS reviews the circumstances of the incident. NMFS will work with 86 FWS to determine whether additional mitigation measures or modifications to the activities are appropriate.

iii. In the event that 86 FWS discovers an injured or dead marine mammal, and the lead observer determines that the injury or death is not associated with or related to the activities authorized in the IHA (*e.g.*, previously wounded animal, carcass with moderate to advanced decomposition, scavenger damage), 86 FWS shall report the incident to the Office of Protected Resources, NMFS, and the Pacific Islands Regional Stranding Coordinator, NMFS, within 24 hours of the discovery. 86 FWS shall provide photographs or video footage or other documentation of the stranded animal sighting to NMFS.

9. Additional Conditions

- The holder of this Authorization must inform the Office of Protected Resources, National Marine Fisheries Service, (301-427-8496) prior to the initiation of any changes to the monitoring plan for a specified mission activity.
- A copy of this Authorization must be in the possession of the safety officer on duty when long range strike missions are conducted.
- This Authorization may be modified, suspended or withdrawn if the holder fails to abide by the conditions prescribed herein, or if NMFS determines the authorized taking is having more than a negligible impact on the species or stock of affected marine mammals.

Table 1. Authorized Take Numbers.

Species	Level A Takes	Level B Takes
Dwarf sperm whale	1	73
Pygmy sperm whale	0	29
Fraser's dolphin	0	1
Minke whale	0	3
Humpback whale	0	12
Total	1	118

Donna S Wieting

SEP 27 2016

Donna S. Wieting

Date

Director, Office of Protected Resources,

National Marine Fisheries Service.

Long Range Strike WSEP Biological Assessment with Cover Letter (June 15, 2016)

DEPARTMENT OF THE AIR FORCE
AIR FORCE CIVIL ENGINEER CENTER
JOINT BASE SAN ANTONIO LACKLAND TEXAS

AFCEC/CZN
2261 Hughes Ave., Ste. 155
JBSA Lackland, TX 78236-9853

15 June, 2016

Ms. Cathryn E. Tortorici
Chief, ESA Interagency Cooperation Division
Office of Protected Resources
National Marine Fisheries Service
1315 East-West Highway
Silver Spring, MD 20910

SUBJECT: Submission of the Programmatic Biological Assessment for Long Range Strike Weapon Systems Evaluation Program to Initiate Consultation under Section 7 of the Endangered Species Act

Dear Ms. Tortorici,

This letter and attached document is being submitted to the National Marine Fisheries Service to initiate consultation under Section 7 of the Endangered Species Act (ESA) for activities described under the Preferred Alternative in the Long Range Strike Weapon Systems Evaluation Program (WSEP) Environmental Assessment/Overseas Environmental Assessment (EA/OEA). The Programmatic Biological Assessment (BA) analyzes potential impacts to the following ESA-listed species: humpback whale, blue whale, fin whale, sei whale, sperm whale, Hawaiian monk seal, green sea turtle, hawksbill sea turtle, loggerhead sea turtle, olive ridley sea turtle, and leatherback sea turtle.

The Proposed Action would authorize the 86th Fighter Weapon Squadron (86 FWS) to conduct operational evaluations of long range strike weapons and other munitions at the Pacific Missile Range Facility, offshore of Kauai, Hawaii. Live (explosive) and inert (non-explosive) munitions would be released from multiple types of operation aircraft, including bombers and fighter aircraft, within military controlled airspace over the Pacific Ocean. The weapon impact point is approximately 44 nautical miles (NM) from the shore of Kauai within the Barking Sands Underwater Range Extension area. All weapons would impact the water surface, with live ordnance detonating on the water surface, or just below the water surface (approximately 10 feet deep). Net explosive weight for live ordnance ranges from 23 to 300 pounds. The water depth at the weapon impact location is over 4,600 meters. Potential impacts to ESA-listed species from direct strikes, ingestion stressors, and detonation effects have been assessed. Based on the analysis in the Programmatic BA, the Air Force has determined that the Long Range Strike WSEP 2016 missions may affect, but are **not likely to adversely affect** ESA-listed marine mammals and may affect, and are **likely to adversely affect** ESA-listed sea turtles. Furthermore, the Air Force analysis indicates that Long Range Strike WSEP missions proposed for 2017-2021 **may affect, and are likely to adversely affect** ESA-listed marine mammals and sea turtles. Long-term population level effects are not anticipated. Adherence to the mitigations outlined in Chapter 5 of the BA is expected to reduce the potential for adverse impacts to marine mammal and sea turtle populations.

The Air Force would like to thank the National Marine Fisheries Service staff for the assistance and support provided during completion of the Programmatic BA. If you have any questions regarding the proposed activities, conclusions, or analysis presented within the Programmatic BA, please do not hesitate to contact either Ms. Amanda Robydek at (850) 882-8395; amanda.robydek.ctr@us.af.mil or myself at (210) 925-2741; michael.ackerman.2@us.af.mil

Sincerely,

Michael Ackerman
Program Manager
NEPA Division (AFCEC/CZN)

ATTACHMENT: Long Range Strike Weapon Systems Evaluation Program Programmatic Biological Assessment

CC: Lt. Col. Sean B. Neitzke, Commander, 86 Fighter Weapon Squadron

LONG RANGE STRIKE WEAPON SYSTEMS EVALUATION PROGRAM AT THE PACIFIC MISSILE RANGE FACILITY AT KAUAI, HAWAII

BIOLOGICAL ASSESSMENT

Submitted To:

ESA Interagency Cooperation Division
Office of Protected Resources
National Marine Fisheries Service
1315 East-West Highway
Silver Spring, MD 20910

Submitted By:

Department of the Air Force

JUNE 2016

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

GLOSSARY OF ACRONYMS, ABBREVIATIONS, AND SYMBOLS

≤	less than or equal to
>	greater than
°	degrees
° N	degrees North
° S	degrees South
° W	degrees West
86 FWS	86th Fighter Weapons Squadron
AFB	Air Force Base
AFCEC	Air Force Civil Engineer Center
Air Force	U.S. Air Force
BSURE	Barking Sands Underwater Range Extension
CFR	Code of Federal Regulations
CV	coefficient of variation
D	water depth (meters)
dB	decibels
dB re 1 μPa	decibels referenced to 1 micropascal
dB re 1 μPa @ 1 m	decibels referenced to 1 micropascal at 1 meter
dB re 1 $\mu Pa^2 \cdot s$	decibels referenced to 1 micropascal-squared second
DoD	Department of Defense
DPS	distinct population segment
EA	Environmental Assessment
EA/OEA	Environmental Assessment/Overseas Environmental Assessment
EEZ	Exclusive Economic Zone
ER	Extended Range
ESA	Endangered Species Act of 1973
FTS	flight termination system
GI	gastrointestinal
GPS	Global Positioning System
HARM	High-Speed Anti-Radiation Missile
HICEAS	Hawaiian Islands Cetacean and Ecosystem Assessment
HRC	Hawaii Range Complex
Hz	hertz
IHA	Incidental Harassment Authorization
INS	internal navigation system
JASSM	Joint Air-to-Surface Stand-off Missile
JASSM-ER	Joint Air-to-Surface Stand-Off Missile-Extended Range
JB	Joint Base
JDAM	Joint Direct Attack Munition
kg	kilograms
kHz	Kilohertz
km	kilometers
km^2	square kilometers
lb	pounds
LJDAM	Laser Joint Direct Attack Munition
LOA	Letter of Authorization
m	meters
M	animal mass based on species (kilograms)
MALD	Miniature Air Launched Decoy
MALD-J	Miniature Air Launched Decoy–Jamming
mi^2	square miles
MMPA	Marine Mammal Protection Act
MSL	mean sea level
n/a	not available
N/A	not applicable

NAS	Naval Air Station
NMSDD	Navy Marine Species Density Database
NEW	net explosive weight
NM	nautical miles
NM^2	square nautical miles
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOTAM	Notice to Airmen
NOTMAR	Notice to Mariners
Pa·s	pascal-seconds
PMRF	Pacific Missile Range Facility
psi·msec	pounds per square inch per millisecond
PTS	permanent threshold shift
SDB	Small Diameter Bomb
SDB-I/II	Small Diameter Bomb-I/II
SDB-I/SDB-II	Small Diameter Bomb-I/Small Diameter Bomb-II
SEL	sound exposure level
SPL	sound pressure level
TM	telemetry
TNT	2,4,6-trinitrotoluene
TTS	temporary threshold shift
USC	United States Code
USFWS	U.S. Fish and Wildlife Service
W-	Warning Area
WSEP	Weapon Systems Evaluation Program

EXECUTIVE SUMMARY

The purpose of this document is to support the consultation process for the Endangered Species Act (ESA) for the Preferred Alternative in the *Environmental Assessment/Overseas Environmental Assessment (EA/OEA) for the Long Range Strike Weapon Systems Evaluation Program (WSEP).* Compliance with the Marine Mammal Protection Act will be accomplished by submitting a request for a Letter of Authorization. Compliance with the Magnuson-Stevens Fishery Conservation and Management Act (MSA) will be accomplished by preparation of a separate Essential Fish Habitat Assessment. Actions covered in the EA/OEA consist of air-to-surface weapon employment in the Barking Sands Underwater Range Extension (BSURE) area of the Pacific Missile Range Facility (PMRF), offshore of Kauai, Hawaii. The purpose of the Proposed Action is to authorize the Air Force to conduct operational evaluations of long range strike weapons and other munitions as part of Long Range Strike WSEP operations. The need for the Proposed Action is to properly train units to execute requirements within Designed Operational Capability Statements, which describe units' real-world operational expectations in a time of war.

Long Range Strike WSEP missions involve the use of multiple types of live (explosive) and inert (non-explosive) munitions (bombs and missiles) scored at the water surface in the BSURE. The ordnance may be delivered by multiple types of aircraft, including bombers and fighter aircraft. Weapon performance will be evaluated by an underwater acoustic hydrophone array system as the weapons strike the water surface and detonate. Net explosive weight of the live munitions ranges from 23 to 300 pounds and detonations may occur on the water surface, or approximately 10 feet below the surface. It is anticipated that missions will occur during summer or early fall. All missions will be conducted during daylight hours. The Long Range Strike WSEP impact area is approximately 44 nautical miles (81 kilometers) offshore of Kauai, Hawaii, in a water depth of about 15,240 feet (4,645 meters).

Acoustic modeling of surface and subsurface detonations indicates the potential for injury and non-injurious harassment to ESA-listed marine mammal and sea turtle species in the absence of mitigation measures. Potential takes, described in Section 4, represent the maximum expected number of animals that could be affected each year. Potential impacts are analyzed separately for missions proposed for 2016 and for missions proposed for 2017–2021. For 2016 missions, acoustic modeling results indicate there would be no marine mammal exposures for any criterion or threshold, and a total of one sea turtle exposure (temporary threshold shift). For 2017–2021 missions, modeling results indicate 2 TTS exposures and 4 behavioral harassment exposures to marine mammals annually. There would be no mortality or Level A injurious harassment. Modeling results also indicate 1 PTS and 15 TTS exposures for sea turtles. Other potential impacts to marine mammals and sea turtles include physical strikes and ingestion stressors. The mitigations outlined in Section 5 are expected to decrease the number of individuals (primarily marine mammals) affected. Although critical habitat for the Hawaiian monk seal (*Neomonachus schauinslandi*) occurs around Kauai, the action area does not include critical habitat.

Based on the analysis in Section 4, the Air Force has determined that Long Range Strike WSEP mission activities proposed for 2016 **may affect, but are not likely to adversely affect** ESA-listed marine mammal species, and **are likely to adversely affect** ESA-listed sea turtle species that occur in the action area. Furthermore, the Air Force has also determined that Long Range Strike WSEP mission activities for 2017–2021 **may affect and are likely to adversely affect** ESA-listed marine mammal and sea turtle species that occur in the action area. Adherence to mitigation measures outlined in Chapter 5 is expected to significantly reduce the potential for adverse effects and long-term population level impacts to marine mammal stocks and sea turtle species are not expected to occur.

1.0 Introduction

1.1 Purpose and Need for the Proposed Action

This Biological Assessment (BA) is being submitted to fulfill requirements under Section 7 of the Endangered Species Act (ESA). This document addresses air-to-surface missions using live ordnance in the Pacific Missile Range Facility (PMRF), as described in the associated *Environmental Assessment/Overseas Environmental Assessment (EA/OEA) for the Long Range Strike Weapon Systems Evaluation Program* (hereafter referred to as the Long Range Strike WSEP EA/OEA). This BA document is meant to initiate the formal consultation process with the National Marine Fisheries Service (NMFS) pursuant to Section 7 of the ESA. The objectives of this BA are to:

- Document all federally listed threatened and endangered (T&E) species and critical habitat that potentially occur within the affected area.
- Identify the actions, as described in the associated EA/OEA, which have the potential to impact, either beneficially or adversely, the documented species and critical habitat.

The Proposed Action of the associated EA/OEA consists of missions involving the use of live or inert munitions primarily deployed on or slightly below the water surface. The actions are described in detail in Section 2, *Description of the Proposed Action*, of this document.

1.2 Scope of the Proposed Action

All activities included in this document correspond to the missions described as the Proposed Action of the associated Long Range Strike WSEP EA/OEA. All activities will take place within the PMRF, which is located in Hawaii on and off the western shores of the island of Kauai in the Pacific Ocean and includes broad ocean areas to the north, south, and west (Figure 1-1). There would be no ground-based or nearshore activities requiring the use of any shoreline areas of Kauai; all aspects and associated impacts from Long Range Strike WSEP missions would occur over open ocean areas. The PMRF, as part of the U.S. Navy's Hawaii Range Complex (HRC), is a Major Range and Test Facility Base and, as such, supports the full spectrum of Department of Defense (DoD) test and evaluation requirements. PMRF is also the world's largest instrumented, multi-environment military testing and training range capable of supporting subsurface, surface, air, and space operations. The PMRF includes 1,020 square nautical miles (NM^2) of instrumented ocean areas at depths between 1,800 feet (549 meters [m]) and 15,000 feet (4,572 m), 42,000 NM^2 of controlled airspace, and a temporary operating area covering 2.1 million NM^2 of ocean area.

Within the PMRF, activities would specifically occur in the Barking Sands Underwater Range Extension (BSURE) area, which lies in Warning Area 188A (W-188A) (Figure 1-2). The BSURE consists of about 900 NM^2 of instrumented underwater ranges, encompassing the deepwater portion of the PMRF and providing over 80 percent of PMRF's underwater scoring capability. The BSURE facilitates training, tactics, development, and test and evaluation for air, surface, and subsurface weapons systems in deep water. It provides a full spectrum of range support, including radar, underwater instrumentation, telemetry, electronic warfare, remote target command and control, communications, data display and processing, and target/weapon launching and recovery facilities. The underwater tracking system begins 9 NM (17 kilometers [km]) from the north shore of Kauai and extends out to 50 NM (93 km) from shore. Long Range Strike WSEP missions would employ live weapons with long flight paths that require large amounts of airspace and would conclude with weapon impact and surface detonations within the BSURE instrumented range. In this document, the BSURE may also be referred to as the Study Area.

Figure 1-1. Regional Location of Long Range Strike WSEP Evaluation Activities

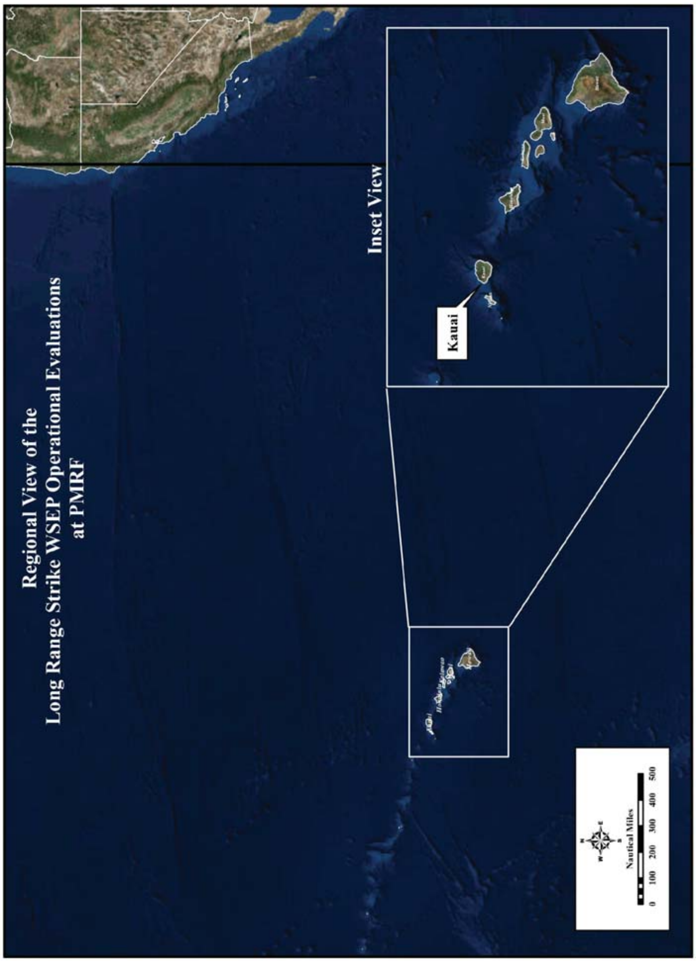
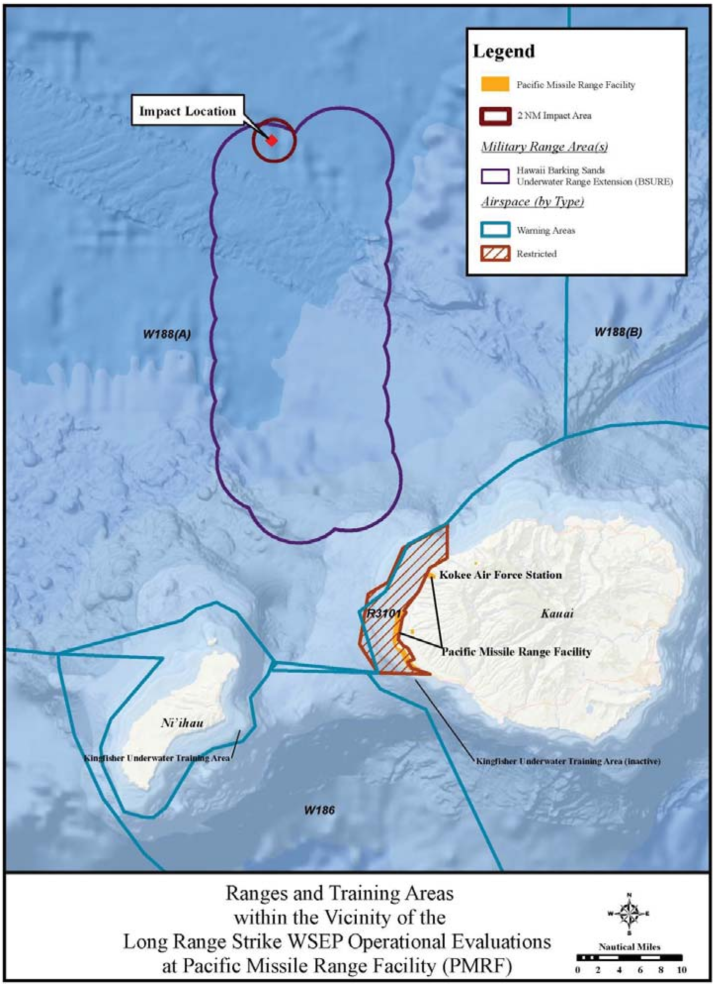


Figure 1-2. Pacific Missile Range Facility on Kauai, Hawaii



1.3 Federally Listed Species Potentially in the Action Area

Marine species protected under the ESA with reasonable potential to be affected by the proposed activities in the Study Area include marine mammals and sea turtles (Table 1-1). Multiple marine mammal stocks are designated in the Hawaii region for some species. A stock is defined as "a group of marine mammals of the same species or smaller taxon in a common spatial arrangement that interbreed when mature." Generally, a stock is considered an isolated population or group of individuals within a whole species that is found in the same area. Stock boundaries are generally based on water depth or distance from shore. Therefore, due to the Long Range Strike WSEP impact site location, not all stocks coincide with the mission area. Three false killer whale (*Pseudorca crassidens*) stocks occur in the vicinity of the Hawaiian Islands and one of these, the Main Hawaiian Islands Insular stock, is listed as endangered under the ESA. The offshore boundary for this stock is delineated at a maximum distance of 39 NM (72 km) offshore, which does not overlap with the Long Range Strike weapon impact location or surrounding potential effects range for missions conducted in 2016 (see Section 2 for a description of different mission activities during the time periods of 2016 and 2017–2021). However, for 2017–2021 missions, the behavioral harassment threshold range extends into the Main Hawaiian Islands Insular stock boundary by less than 2 km. No other threshold ranges extend into the stock boundary. Therefore, false killer whales are included in the evaluation of potential behavioral effects in this document.

All marine mammals receive protection under the Marine Mammal Protection Act of 1972 (MMPA). Impacts to marine mammals have been generally addressed in a separate Letter of Authorization request submitted to NMFS's Office of Protected Resources. No fish species protected under the ESA occur in the BSURE area. Seabird species, including species protected under the ESA, occur in the Hawaii region and, therefore, could potentially occur in the Study Area. However, due to the relatively low number of total detonations, including a very low number of in-air detonations (four per year), the likelihood of birds being present at the impact area at the time of an explosion is considered remote. In addition, there would be no on-water targets to provide resting surfaces for birds. Seabirds are, therefore, not considered further in this document. The listed species addressed in this BA are provided in Table 1-1, and descriptions of each species are presented in Section 3, *Species Descriptions*.

Table 1-1. Federally Protected Species with Potential Occurrence in the Study Area

Species Common Name	Species Scientific Name	ESA Status
Marine Mammals		
Humpback whale	*Megaptera novaeangliae*	Endangered
Blue whale	*Balaenoptera musculus*	Endangered
Fin whale	*Balaenoptera physalus*	Endangered
Sei whale	*Balaenoptera borealis*	Endangered
Sperm whale	*Physeter macrocephalus*	Endangered
False killer whale	*Pseudorca crassidens*	Endangered
Hawaiian monk seal	*Neomonachus schauinslandi*	Endangered
Sea Turtles		
Green sea turtle	*Chelonia mydas*	Threatened
Hawksbill sea turtle	*Eretmochelys imbricata*	Endangered
Loggerhead sea turtle	*Caretta caretta*	Endangered
Olive ridley sea turtle	*Lepidochelys olivacea*	Threatened
Leatherback sea turtle	*Dermochelys coriacea*	Endangered

1.4 Applicable Regulatory Requirements and Coordination

The acts and regulations described below are applicable to the activities included in this document.

1.4.1 National Environmental Policy Act

The National Environmental Policy Act (NEPA) requires federal agencies to consider the environmental consequences of proposed actions in the decision-making process (42 United States Code [USC] 4321, et seq.). The Council on Environmental Quality (CEQ) was established under NEPA to implement and oversee federal policy in this process. In 1978, the CEQ issued regulations implementing the NEPA process under Title 40, Code of Federal Regulations (CFR), Parts 1500–1508. The CEQ regulations require that the federal agency considering an action must evaluate or assess the potential consequences of the action or alternatives to the action, which may result in the need for an EA or environmental impact statement (EIS). Under 40 CFR:

- An EA must briefly provide sufficient evidence and analysis to determine whether a finding of no significant impact or EIS should be prepared.
- An EA must facilitate the preparation of an EIS if required.

The proposed activities addressed in this document constitute a federal action and, therefore, must be assessed in accordance with NEPA. To comply with NEPA, as well as other applicable environmental requirements, the decision-making process for the Proposed Action must include the development of an EA to address the environmental issues related to the proposed activities. The Air Force Environmental Impact Analysis Process is accomplished via procedures set forth in CEQ regulations and 32 CFR Part 989. The Air Force has prepared the associated Long Range Strike WSEP EA/OEA pursuant to NEPA requirements.

1.4.2 Executive Order 12114

Executive Order 12114, *Environmental Impacts Abroad of Major Federal Actions*, directs federal agencies to provide for informed environmental decision making for major federal actions outside the United States and its territories. Presidential Proclamation 5928, issued December 27, 1988, extended the exercise of U.S. sovereignty and jurisdiction under international law to 12 NM; however, the proclamation expressly provides that it does not extend or otherwise alter existing federal law or any associated jurisdiction, rights, legal interests, or obligations. Thus, as a matter of policy, the Air Force analyzes environmental effects and actions within 12 NM under NEPA and those effects occurring beyond 12 NM under the provisions of Executive Order 12114. Most of the actions described in this document will occur beyond the 12-NM boundary.

1.4.3 Endangered Species Act of 1973

The purpose of the ESA, as amended, is to protect fish, wildlife, and plant species currently in danger of extinction and those species that may become so in the foreseeable future. The ESA states that "…it is unlawful for any person subject to the jurisdiction of the United States to…*take* any such species within the United States or the territorial sea of the United States" or *take* any such species upon the high seas." The term *take* is defined as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect or attempt to engage in any such conduct." Each federal agency is required to review its actions at the earliest possible time to determine whether any action it authorizes, funds, or carries out may affect listed species or critical habitat. If such a determination is made, consultation with the appropriate agency is required.

The U.S. Fish and Wildlife Service (USFWS) and NMFS share responsibilities for administering the Act, with NMFS generally coordinating ESA activities for marine and anadromous species and the USFWS coordinating ESA activities for terrestrial and freshwater species. ESA responsibilities regarding sea turtles are further split between the two agencies; NMFS coordinates activities that could impact turtles in the marine environment, while the USFWS is responsible for turtle nesting activities. Activities associated with the air-to-surface missions described in this document will only affect offshore marine areas. Therefore, consultation with NMFS is applicable.

2.0 Description of the Proposed Action

Due to threats to national security, increased testing and training missions involving air-to-surface activities have been directed by the DoD. Accordingly, the Air Force seeks the ability to conduct operational evaluations of all phases of long range strike weapons and other munitions within the HRC. The actions would fulfill the Air Force's requirement to evaluate full-scale maneuvers for such weapons, including scoring capabilities, under operationally realistic scenarios.

The action will take place in the BSURE area of the PMRF, offshore of Kauai, Hawaii. Missions are planned to begin in summer 2016 and continue for the following five years. The 86th Fighter Weapons Squadron (86 FWS) is the test execution organization under the 53rd Wing for all WSEP deployments. WSEP test objectives are to evaluate air-to-surface and maritime weapon employment data, evaluate tactics, techniques, and procedures in an operationally realistic environment, and to determine the impact of tactics, techniques, and procedures on combat Air Force training. The munitions associated with the proposed activities are not part of a typical unit's training allocations, and prior to attending a WSEP evaluation, most pilots and weapon systems officers have only dropped weapons in simulators or used the aircraft's simulation mode. Without WSEP operations, pilots would be using these weapons for the first time in combat. On average, half of the participants in each unit drop an actual weapon for the first time during a WSEP evaluation. Consequently, WSEP is a military readiness activity and is the last opportunity for squadrons to receive operational training and evaluation before they deploy.

In this document, air-to-surface activities refer to the deployment of missiles and bombs from aircraft to the water surface. Depending on the requirements of a given mission, munitions may be inert (containing no explosives or only a "spotting" charge) or live (contain explosive charges). Live munitions may detonate at, or slightly below the water surface. The following subsections describe aircraft operations, weapons used, and typical mission procedures.

2.1 Aircraft Operations

Aircraft used for munition releases would include bombers and fighter aircraft. Additional airborne assets, such as the P-3 Orion or the P-8 Poseidon, would be used to relay telemetry (TM) and flight termination system (FTS) streams between the weapon and ground stations. Other support aircraft would be associated with range clearance activities before and during the mission and with air-to-air refueling operations. All weapon delivery aircraft would originate from an out base and fly into military controlled airspace prior to employment. Due to long transit times between the out base and mission location, air-to-air refueling may be conducted in either W-188 or W-189. Bombers, such as the B-1, would deliver the weapons, conduct air-to-air refueling, and return to their originating base as part of one sortie. However, when fighter aircraft are used, the distance and corresponding transit time to the various potential originating bases would make return flights after each mission day impractical. In these cases, the aircraft would temporarily (less than one week) park overnight at Hickam Air Force Base (AFB) and would return to their home base at the conclusion of each mission set. Multiple weapon-release aircraft would be used during each mission, each potentially releasing multiple munitions. Each Long Range Strike WSEP mission set would occur over a maximum of five consecutive days per year. Approximately 10 Air Force personnel would be on temporary duty to support each mission set. Table 2-1 summarizes potential aircraft use proposed to support Long Range Strike WSEP missions.

Table 2-1. Summary of Aircraft Usage During Long Range WSEP Missions

Type	Example Aircraft	Purpose	Potential Outbases
Bombers	B-1, B-2, B-52	Weapon release	Ellsworth AFB; Dyess AFB; Barksdale AFB; Whiteman AFB; Minot AFB
Fighter aircraft	F-15, F-16, F-22, F-35	Weapon release, chase aircraft, range clearance	Mountain Home AFB; Nellis AFB; Hill AFB; JB Hickam-Pearl Harbor; JB Elmendorf-Richardson; JB Langley-Eustis
Refueling tankers	KC-135	Air-to-air refueling	McConnell AFB
Surveillance	P-3, P-8	TM and FTS relays	Pt. Mugu, NAS
Helicopters	S-61N	Range clearance, protected species surveys	PMRF
Cargo aircraft	C-130, C-26	Range clearance, protected species surveys	U.S. Coast Guard; PMRF

AFB = Air Force Base; FTS = flight termination system; JB = Joint Base; NAS = Naval Air Station; PMRF = Pacific Missile Range Facility; TM = telemetry

Aircraft flight maneuver operations and weapon release would be conducted in W-188A. Chase aircraft may be used to evaluate weapon release and to track weapons. Flight operations and weapons delivery would be in accordance with published Air Force directives and weapon operational release parameters, as well as all applicable Navy safety regulations and criteria established specifically for PMRF. Aircraft supporting Long Range Strike WSEP missions would primarily operate at high altitudes—only flying below 3,000 for a limited time as needed to escort non-military vessels outside the hazard area or for monitoring the area for protected marine species (e.g., marine mammals and sea turtles). Protected marine species aerial surveys would focus on an area surrounding the weapon impact point on the water. Post-mission surveys would focus on the area down current of the weapon impact location. Range clearance procedures for each mission would cover a much larger area for human safety. Weapon release parameters would be conducted as approved by PMRF Range Safety. Weapon release parameters would be conducted as approved by PMRF Range Safety. Daily mission briefs would specify planned release conditions for each mission. Aircraft and weapons would be tracked for time, space, and position information. The 86 FWS test director would coordinate with the PMRF Range Safety Officer, Operations Conductor, Range Facility Control Officer, and other applicable mission control personnel for aircraft control, range clearance, and mission safety. Figure 2-1 shows a photograph taken from a chase aircraft of a long range missile being released and in flight.

Figure 2-1. Joint Air-to-Surface Stand-Off Missile (JASSM) Released

2.2 Description of Long Range Strike Weapons

Long Range Strike WSEP missions would release live (explosive) and inert (non-explosive) Joint Air-to-Surface Stand-Off Missile / Joint Air-to-Surface Stand-Off Missile-Extended Range (JASSM/ ER), Small Diameter Bomb-I/II (SDB-I/II), High-Speed Anti-Radiation Missile (HARM), Joint Direct Attack Munition/Laser Joint Direct Attack Munition (JDAM/LJDAM), and Miniature Air Launched Decoy/Miniature Air Launched Decoy–Jamming (MALD/MALD-J). A description of each munition is included in the following subsections.

JASSM/JASSM-ER

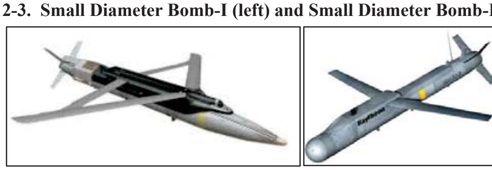
The JASSM (Figure 2-2) is a stealthy precision cruise missile designed for launch outside area defenses against hardened, medium-hardened, soft, and area type targets. The JASSM has a range of more than 200 NM (370 km) and carries a 1,000-pound warhead with approximately 300 pounds of 2,4,6-trinitrotoluene (TNT) equivalent net explosive weight (NEW). The specific explosive used is AFX-757, a type of plastic bonded explosive (PBX). The weapon has the capability to fly a preprogrammed route from launch to a target, using Global Positioning System (GPS) technology and an internal navigation system (INS) combined with a Terminal Area Model when available. Additionally, the weapon has a Common Low Observable Auto-Routing function that gives the weapon the ability to find the route that best utilizes the low observable qualities of the JASSM. In either case, these routes can be modeled prior to weapon release. The JASSM-ER has additional fuel and a different engine for a greater range than the JASSM (500 NM [926 km]) but maintains the same functionality of the JASSM.

Figure 2-2. Joint Air-to-Surface Stand-Off Missile (JASSM)

SDB-I/SDB-II

The SDB I (Figure 2-3) is a 250-pound air-launched GPS-INS guided weapon for fixed soft to hardened targets. SDB II (Figure 2-3) expands the SDB I capability with network enabling and uses a tri-mode sensor infrared, millimeter, and semi-active laser to attack both fixed and movable targets. Both munitions have a range of up to 60 NM (111 km). The SDB-I contains 37 pounds of TNT-equivalent NEW, and the SDB-II contains 23 pounds NEW. The explosive used in both the SDB-I and SDB-II is AFX-757.

Figure 2-3. Small Diameter Bomb-I (left) and Small Diameter Bomb-II (right)



HARM

The HARM (Figure 2-4) is a supersonic air-to-surface missile designed to seek and destroy enemy radar-equipped air defense systems. The HARM has a proportional guidance system that homes in on enemy radar emissions through fixed antenna and seeker head in the missile nose. It has a range of up to 80 NM (148 km) and contains 45 pounds of TNT-equivalent NEW. The explosive used is PBXN-107.

Figure 2-4. High Anti-Radiation Missile (HARM)

JDAM/LJDAM

The JDAM (Figure 2-5) is a smart GPS-INS weapon that uses an unguided gravity bomb and adds a guidance and control kit, converting it to a precision-guided munition. The LJDAM variant adds a laser sensor to the JDAM, permitting guidance to a laser designated target. Both JDAM and LJDAM contain 192 pounds of TNT-equivalent NEW with multiple fusing options, with detonations occurring upon impact or with up to a 10-millisecond delay.

Figure 2-5. Joint Direct Attack Munition (JDAM)

MALD/MALD-J

The MALD (Figure 2-6) is an air-launched, expendable decoy that will provide the Air Force the capability to simulate, deceive, decoy, and saturate an enemy's threat integrated air defense system (IADS). The MALD production has recently transitioned to include the MALD-J variant, which has the same decoy capability of the MALD plus the addition of jamming IADS. The MALD and MALD-J have ranges up to 500 NM (926 km) to include a 200-NM (370-km) dash with a 30-minute loiter mode. It has no warhead and, therefore, no detonation upon impact with the water surface would occur.

Figure 2-6. Miniature Air Launched Decoy (MALD/MALD-J)

2.3 Schedule and General Mission Procedures

Initial phases of the Long Range Strike WSEP operational evaluations are scheduled for September 2016 and will only consist of releasing one live JASSM/JASSM-ER and eight SDB I. All live releases for 2016 would result in surface detonations. Follow-on evaluations planned for 2017 through 2021 will add deployments of live SDB-II, HARM, JDAM, and MALD, in addition to continued evaluation of JASSM/JASSM-ER and SDB-I. Releases of live ordnance associated with 2017–2021 missions would result in either surface or subsurface detonations (10-foot [3-m] water depth).

A typical mission day would consist of pre-mission checks, safety review, crew briefings, weather checks, clearing airspace, range clearance, mitigations/monitoring efforts, and other military protocols prior to launch of weapons. Potential delays could be the result of multiple factors including, but not limited to, adverse weather conditions leading to unsafe take-off, landing, and aircraft operations, inability to clear the range of non-mission vessels or aircraft, mechanical issues with mission aircraft or munitions, or presence of protected species in the impact area. These standard operating procedures are usually done in the morning, and live range time may begin in late morning once all checks are complete and approval is granted from range control. The range would be closed to the public for a maximum of four hours per mission day.

Each long range strike weapon would be released in W-188A and would follow a given flight path with programmed GPS waypoints to mark its course in the air. Long range strike weapons would complete their maximum flight range (up to 500-NM distance for JASSM-ER) at an altitude of approximately 18,000 feet above mean sea level (MSL) and terminate at a specified location for scoring of the impact. The cruise time would vary among the munitions, but would be about 45 minutes for JASSM/JASSM-ER and 10 minutes for SDB-I/II. Similarly, the time frame between employments of successive munitions would vary, but releases could be spaced by approximately one hour to account for the JASSM cruise time. The final impact point for all munitions is within the northern portion of the BSURE area, approximately 44 NM (81 km) offshore of Kauai in approximate water depth of 15,240 feet (4,645 meters). The location of W-188A, along with the specific impact point, is shown on Figure 1-2 in Section 1. The routes and associated safety profiles would be contained within W-188A boundaries. The objective of the route designs is to complete full-scale evasive maneuvers that avoid simulated threats and would, therefore, not consist of a standard “paper clip” or regularly shaped route. The final impact point on the water surface would be programmed into the munitions for weapons scoring and evaluations. The JDAM/LJDAM munitions would also be set to impact at the same point on the water surface.

All missions would be conducted in accordance with applicable flight safety, hazard area, and launch parameter requirements established for PMRF. A weapon hazard region would be established, with the size and shape determined by the maximum distance a weapon could travel in any direction during its descent. The hazard area is typically adjusted for potential wind speed and direction, resulting in a maximum composite safety footprint for each mission (each footprint boundary is at least 12 NM from the Kauai coastline). This information is used to establish a Launch Exclusion Area and Aircraft Hazard Area. These exclusion areas must be verified to be clear of all non-mission and non-essential vessels and aircraft before live weapons are released. In addition, a buffer area must also be clear on the water surface so that vessels do not enter the exclusion area during the launch window. Prior to weapon release, a range sweep of the hazard area would be conducted by participating mission aircraft or other appropriate aircraft, potentially including S-61N helicopter, C-26 aircraft, fighter aircraft (F-15E, F-16, F-22), or the Coast Guard’s C-130 aircraft.

PMRF has used small water craft docked at the Port Allen public pier to keep nearshore areas clear of tour boats for some mission launch areas. However, for missions with large hazard areas that occur far offshore from Kauai, it would be impractical for these smaller vessels to conduct range clearance activities. The composite safety footprint weapons associated with Long Range Strike WSEP missions is anticipated to be rather large; therefore, it is likely that range clearing activities would be conducted solely by aircraft.

The Range Facility Control Officer is responsible for establishing hazard clearance areas, directing clearance and surveillance assets, and reporting range status to the Operations Conductor. The Control Officer is also responsible for submitting all Notice to Airmen (NOTAMs) and Notice to Mariners (NOTMARs), and for requesting all Federal Aviation Administration airspace clearances. In addition to the human safety measures described above, protected species surveys are carried out before and after missions, as summarized in Section 5 (*Mitigations*).

Immediate evaluations for JASSM/JASSM-ER and SDB I are needed; therefore, they are the only munitions being proposed for summer 2016 missions, currently set for September. Weapon release parameters for 2016 missions would involve a B-1 bomber releasing one live JASSM and fighter aircraft, such as F-15, F-16, or F-22, releasing eight live SDB-I. Up to four SDB-I munitions would be released simultaneously, similar to a ripple effect, each hitting the water surface within a few seconds of each other; however the SDB-I releases would occur separate from the JASSM. All releases would occur on the same mission day.

Follow-on years (2017–2021) would add evaluations of SDB-II, HARM, JDAM/LJDAM, and MALD/MALD-J munitions, in addition to continued evaluations of JASSM/JASSM-ER and SDB I/II. Similar to what is proposed for 2016 missions, up to four SDB I/II munitions could be released simultaneously, such that each ordnance would hit the water surface within a few seconds of each other. It is not known how many weapon releases or what combination of munitions would be released each day. However, aside from the SDB-I/II releases, all other weapons would be released separately, impacting the water surface at different times.

Table 2-2 summarizes live and inert munition releases planned in the PMRF for 2016–2021.

Table 2-2. Proposed Munitions at PMRF (2016–2021)

Type of Munition	Live or Inert	NEW (lb)	Type of Aircraft	Detonation Scenario	Number of Proposed Releases					
					2016	2017	2018	2019	2020	2121
JASSM/ JASSM-ER	Live	300	Bomber, Fighter	Surface	1	6	6	6	6	6
SDB-I	Live	37	Bomber, Fighter	Surface	8	30	30	30	30	30
SDB-II	Live	23	Bomber, Fighter	Surface	0	30	30	30	30	30
HARM	Live	45	Fighter	Surface	0	10	10	10	10	10
JDAM/LJDAM	Live	192	Bomber, Fighter	Subsurface[1]	0	30	30	30	30	30
MALD/ MALD-J	Inert	N/A	Fighter	N/A	0	4	4	4	4	4

HARM = High Anti-Radiation Missile; JDAM = Joint Direct Attack Munition; lb = pounds; LJDAM = Laser Joint Direct Attack Munition; MALD = Miniature Air Launched Decoy; PMRF = Pacific Missile Range Facility; SDB = Small Diameter Bomb
1. Assumes a 10-millisecond time-delayed fuse resulting in detonation occurring at an approximate 10-foot water depth.

3.0 Species Descriptions

A total of 11 ESA-species are identified as having potential occurrence in the Study Area, including 6 marine mammal species and 5 sea turtle species. These species are described in the following subsections.

3.1 Marine Mammals

This section provides a description of marine mammal species and stocks listed under the ESA that are potentially found in the PMRF, including the BSURE area. In some instances in this section, references are made to various regions of the Pacific Ocean delineated by the National Oceanic and Atmospheric Administration (NOAA)/NMFS Science Centers. The Eastern North Pacific is the area in the Pacific Ocean that is east of 140 degrees (°) west (W) longitude and north of the equator. Similarly the Central North Pacific is the area north of the equator and between the International Date Line (180° W longitude) and 140° W longitude. The Eastern Tropical Pacific is the area roughly extending from the United States-Mexico Border west to Hawaii and south to Peru.

Marine mammals are a diverse group of approximately 130 species that rely wholly or substantially on the sea for important life functions and include cetaceans (whales, dolphins, and porpoises), pinnipeds (seals, sea lions, and walruses), sirenians (manatees, dugongs, and sea cows), marine otters, and polar bears. Of these animal groups, only whales, dolphins, and one pinniped occur in the Study Area. Although most marine mammal species live predominantly in the marine habitat, some spend time in terrestrial habitats (e.g., seals) or freshwater environments (e.g., some freshwater dolphins). Marine mammals may be designated under the ESA as endangered, threatened, candidate, or proposed species.

Cetaceans may be categorized as odontocetes or mysticetes. Odontocetes, which range in size from about 1 m to over 18 m, have teeth that are used to capture and consume individual prey. Mysticetes, which are also known as baleen whales, range in size from about 10 m to over 30 m. Instead of teeth, mysticetes have baleen (a fibrous structure made of keratin) in their mouth which is used to filter the large numbers of small prey that are engulfed, sucked, or skimmed from the water or ocean floor sediments. Cetaceans inhabit virtually every marine environment, from coastal waters to the open ocean. Their distribution is primarily influenced by prey availability, which depends on factors such as ocean current patterns, bottom relief, and sea surface temperature, among others. Most of the large cetaceans are migratory, but many small cetaceans do not migrate in the strictest sense. Instead, they may undergo seasonal dispersal, or shifts in density. Pinnipeds generally spend a large portion of time on land at haulout sites used for resting and moulting, and at rookeries used for breeding and nursing young, and return to the water to forage. The only pinniped species that occurs regularly in Hawaii is the Hawaiian monk seal (*Neomonachus schauinslandi*). In the Main Hawaiian Islands (which includes Kauai), they are generally solitary and have no established rookeries.

General Behavior

Many species of marine mammals, particularly odontocetes, are highly social animals that spend much of their lives living in groups or schools ranging from several individuals to several thousand individuals. Aggregations of baleen whales may form during particular breeding or foraging seasons, although they do not appear to persist over time as a social unit. All marine mammals dive beneath the water surface, primarily for the purpose of foraging. Dive frequency and the time spent during dives vary among species and within individuals of the same species. Some species that forage on deep-water prey can make dives lasting over an hour. Other species spend the majority of their lives close to the surface and make relatively shallow dives. The diving behavior of a particular species or individual has implications regarding the ability to detect them during mitigation and monitoring activities. In addition, their distribution through the water column is an important consideration when conducting acoustic exposure analyses.

Vocalization and Hearing

All marine mammals that have been studied can produce sounds and use sounds to forage, orient, detect and respond to predators, and socially interact with others. Measurements of marine mammal sound production and hearing capabilities provide some basis for assessment of whether exposure to a particular sound source may affect a marine mammal. Marine mammal hearing abilities are quantified using live animals either via behavioral audiometry or electrophysiology. Behavioral audiograms are plots of animals' exhibited hearing threshold versus frequency, and are obtained from captive, trained live animals. Behavioral audiograms are difficult to obtain because many species are too large, too rare, and too difficult to acquire and maintain for experiments in captivity. Electrophysiological audiometry measures small electrical voltages produced by neural activity when the auditory system is stimulated by sound. The technique is relatively fast, does not require a conscious response, and is routinely used to assess the hearing of newborn humans. Understanding of a species' hearing ability may be based on the behavioral audiogram of only a single individual or small group of animals. In addition, captive animals may be exposed to local ambient sounds and other environmental factors that may impact their hearing abilities and may not accurately reflect the hearing abilities of free-swimming animals (Houser et al., 2010b). For animals not available in captive or stranded settings (including large whales and rare species), estimates of hearing capabilities are made based on physiological structures, vocal characteristics, and extrapolations from related species.

Direct measurement of hearing sensitivity exists for only about 25 of the nearly 130 species of marine mammals. Table 3-1 provides a summary of sound production and general hearing capabilities for marine mammals included in this document. For purposes of acoustic analysis, marine mammals are arranged into the following functional hearing groups based on their generalized hearing sensitivities: mid-frequency cetaceans, low-frequency cetaceans, and phocid pinnipeds (true seals). Not all marine mammal functional hearing groups are represented by species included in this document. For a detailed discussion of all functional hearing groups and their derivation, see Finneran and Jenkins (2012).

Table 3-1. Hearing and Vocalization Ranges for Marine Mammal Functional Hearing Groups

Functional Hearing Group	Species Potentially Present in the Study Area	Sound Production		General Hearing Ability Frequency Range
		Frequency Range	Source Level (dB re 1 µPa @ 1 m)	
Mid-Frequency Cetaceans	Sperm Whale, False Killer Whale	100 Hz to >100kHz	118 to 236	150 Hz to 160 kHz
Low-Frequency Cetaceans	Blue Whale, Fin Whale, Humpback Whale, Sei Whale	10 Hz to 20 kHz	129 to 195	7 Hz to 22 kHz
Phocidae	Hawaiian monk seal	100 Hz to 12 kHz	103 to 180	In water: 75 Hz to 75 kHz In air: 75 Hz to 30 kHz

> = greater than; dB re 1 µPa @ 1 m = decibels referenced to 1 microPascal at 1 meter; Hz = hertz; kHz = kilohertz

General Threats

Marine mammal populations can be influenced by various factors and human activities. These factors can affect marine mammal populations directly (e.g., hunting and whale watching), or indirectly (e.g., reduced prey availability or lowered reproductive success). Marine mammals may also be influenced by natural phenomena such as storms and other extreme weather patterns, and climate change. Generally, not much is known about how large storms and other weather patterns affect marine mammals, other than that mass strandings (when two or more marine mammals become beached or stuck in shallow water) sometimes coincide with hurricanes, typhoons, and other tropical storms (Marsh, 1989; Rosel and Watts, 2008). Climate change can potentially affect marine mammal species directly through habitat loss (especially for species that depend on ice or terrestrial areas) and indirectly via impacts on prey, changing prey distributions and locations, and changes in water temperature.

Mass die offs of some marine mammal species have been linked to toxic algal blooms. In such cases, the mammals consume prey that has consumed toxic plankton. All marine mammals have parasites that, under normal circumstances, probably do little overall harm, but that under certain conditions can cause health problems or even death (Jepson et al., 2005; Bull et al., 2006; Fauquier et al., 2009). Disease affects some individuals (especially older animals), and occasionally disease epidemics can injure or kill a large percentage of a population (Paniz-Mondolfi and Sander-Hoffmann, 2009; Keck et al., 2010). Recently the first case of morbillivirus in the central Pacific was documented for a stranded Longman's beaked whale at Hamoa Beach, Hana, Maui (West et al., 2012).

Human impacts on marine mammals have received much attention in recent decades, and include hunting (both commercial and native practices), fisheries interactions (such as gear entanglement or shootings by fishers), bycatch (accidental or incidental catch), indirect effects of fisheries through takes of prey species, ship strikes, noise pollution, chemical pollution, and general habitat deterioration or destruction. Direct hunting, as in whaling and sealing operations, provided the original impetus for marine mammal management efforts and has driven much of the early research on cetaceans and pinnipeds (Twiss and Reeves, 1999). In 1994, the MMPA was amended to formally address bycatch. Cetacean bycatch subsequently declined by 85 percent between 1994 and 2006. However, fishery bycatch is likely the most impactful problem presently and may account for the deaths of more marine mammals than any other cause (Northridge, 2008; Read, 2008; Hamer et al., 2010; Geijer and Read, 2013). For example, bycatch has significantly contributed to the decline of the Hawaiian population of false killer whales (Boggs et al., 2010).

Ship strikes are an issue of increasing concern for most marine mammals, particularly baleen whale species. There were nine reported ship collisions with humpback whales in the Hawaiian Islands in 2006 (none involved Navy vessels), as recorded by the NMFS Pacific Islands Region Marine Mammal Response Network Activity Updates (National Marine Fisheries Service, 2007a). Overall, from 2007-2012 in Hawaii, there were 39 vessel collisions involving humpback whales (Bradford and Lyman, 2015). None of these strikes involved Navy vessels. A humpback carcass was discovered on the shore of southwest Molokai in 2010 with indications that the death resulted from trauma consistent with a ship strike (National Marine Fisheries Service, 2010e). Chemical pollution is also of concern, although for the most part, its effects on marine mammals are not well understood (Aguilar de Soto et al., 2008). Chemical pollutants found in pesticides flow into the marine environment from human use on land and are absorbed into the bodies of marine mammals, accumulating in their blubber or internal organs, or are transferred to the young from its mother's milk (Fair et al., 2010). Marine mammals that live closer to the source of pollutants and those that feed on higher-level organisms have increased potential to accumulate toxins (Moon et al., 2010). The buildup of human-made persistent compounds in marine mammals not only increases their likelihood of contracting diseases or developing tumors, but also compromises the function of their reproductive systems (Fair et al., 2010). Oil and other chemical spills are a specific type of ocean contamination that can have damaging effects on some marine mammal species (see Matkin et al., 2008).

Habitat deterioration and loss is a major factor for almost all coastal and inshore species of marine mammals, especially those that live in rivers or estuaries, and it may include such factors as depleting a habitat's prey base and the complete loss of habitat (Kemp, 1996; Smith et al., 2009; Ayres et al., 2012). In some locations, especially where urban or industrial activities or commercial shipping is intense, anthropogenic noise is also being increasingly considered as a potential habitat level stressor. Noise is of particular concern to marine mammals because many species use sound as a primary sense for navigating, finding prey, avoiding predators, and communicating with other individuals. Noise may cause marine mammals to leave a habitat, impair their ability to communicate, or cause stress (Hildebrand, 2009 Tyack et al., 2011; Rolland et al., 2012; Erbe et al., 2012). Noise can cause behavioral disturbances, mask other sounds including their own vocalizations, may result in injury and in some cases, may result in behaviors that ultimately lead to death (National Research Council, 2003; National Research Council 2005; Nowacek et al., 2007; Würsig and Richardson, 2009; Southall et al., 2009; Tyack, 2009). Anthropogenic noise is generated from a variety of sources including commercial shipping, oil and gas activities, commercial and recreational fishing, recreational boating and whale watching, offshore power generation, research (including sound from air guns, sonar, and telemetry), and military training and testing activities. Vessel noise in particular is a large contributor to noise in the ocean. Commercial shipping's contribution to ambient noise in the ocean has increased by as much as 12 dB over the last few decades (McDonald et al., 2008; Hildebrand, 2009).

Marine mammals as a whole are subject to the various influences and factors described above. If additional specific threats to individual species within the Study Area are known, those threats are described below in the descriptive accounts of those species.

General Occurrence in the Study Area

There are seven marine mammal species listed under the ESA with potential occurrence in the Study Area, including four mysticetes (baleen whales), two odontocetes (dolphins and toothed whales), and one pinniped (Table 3-2). Information on status, distribution, abundance, and ecology of these species is presented in the following subsections.

3.1.1 Humpback Whale (*Megaptera novaeangliae*)

Status and Management

Humpback whales are currently listed as depleted under the MMPA and endangered under the ESA. In the U.S. North Pacific Ocean, the stock structure of humpback whales is defined based on feeding areas because of the species' fidelity to feeding grounds (Carretta et al., 2015). Three stocks are currently designated by NMFS in the North Pacific: (1) the Central North Pacific stock, consisting of winter and spring populations of the Hawaiian Islands that migrate to northern British Columbia and Alaska, the Gulf of Alaska, the Bering Sea, and Aleutian Islands; (2) the Western North Pacific stock, consisting of winter and spring populations off Asia that migrate to Russia and the Bering Sea and Aleutian Islands; and (3) the California/Oregon/Washington stock, consisting of animals along the U.S. west coast.

However, in April 2015, NMFS announced a proposal to divide the species into 14 distinct population segment (DPSs), including a Hawaii DPS, and to revise the listing status for the various segments (50 Code of Federal Regulations (CFR) Parts 223 and 224, 21 April 2015). Under the proposal, two DPSs would be designated as endangered under the ESA, two would be designated as threatened, and the remainder would not have an ESA listing status. The proposed Hawaii DPS, which is the same as the current Central North Pacific stock, is not included in the four DPSs that would be listed under the ESA. NMFS does not consider the proposed Hawaii DPS to be in danger of extinction, or likely to become so in the foreseeable future. Therefore, the DPS would not be listed as endangered or threatened under the proposed revision. At the time this document was prepared, NMFS was soliciting public comment on the proposed rule.

The Hawaiian Islands Humpback Whale National Marine Sanctuary, which was designated in 1992 to protect humpback whales and their habitat, is located within the HRC. The sanctuary is delineated from the shoreline to the 100-fathom (183 m) isobath in discrete areas of the Hawaiian Islands region, including an area off the north shore of Kauai. However, the sanctuary does not coincide with the Long Range WSEP mission location, which is located in water depth of over 4,600 meters.

Geographic Range and Distribution

General. Humpback whales are distributed worldwide in all major oceans and most seas. They typically are found during the summer in high-latitude feeding grounds and during the winter in the tropics and subtropics around islands, over shallow banks, and along continental coasts, where calving occurs.

Table 3-2. Marine Mammals Species and Stocks Listed Under the ESA with Potential Occurrence in the Study Area

Common Name	Scientific Name	Stock	Stock Abundance[a] (CV)[b]	Study Area Abundance[a] (CV)[b]	Occurrence	ESA Status
Mysticetes (baleen whales)						
Humpback whale	*Megaptera novaeangliae*	Central North Pacific	10,103 (N/A)	4,491 (N/A)	Seasonal; throughout known breeding grounds during winter and spring (most common November through April)	Endangered
Blue whale	*Balaenoptera musculus*	Central North Pacific	81 (summer/fall) (1.14)	81 (summer/fall) (1.14)	Seasonal; infrequent winter migrant; few sightings, mainly fall and winter; considered rare	Endangered
Fin whale	*Balaenoptera physalus*	Hawaii	58 (summer/fall) (1.12)	58 (summer/fall) (1.12)	Seasonal, mainly fall and winter; considered rare	Endangered
Sei whale	*Balaenoptera borealis*	Hawaii	178 (summer/fall) (0.90)	178 (summer/fall) (0.90)	Rare; limited sightings of seasonal migrants that feed at higher latitudes	Endangered
Odontocetes (toothed whales and dolphins)						
Sperm whale	*Physeter macrocephalus*	Hawaii	3,354 (0.34)	3,354 (0.34)	Widely distributed year-round; more likely in waters > 1,000 m depth, most often > 2,000 m	Endangered
False killer whale	*Pseudorca crassidens*	Main Hawaiian Islands Insular	151 (0.20)	151 (0.20)	Regular	Endangered
Pinnipeds						
Hawaiian monk seal	*Neomonachus schauinslandi*	Hawaii	1,153 (Northwestern Hawaiian Islands)	138 (Main Hawaiian Islands)	Predominantly occur at Northwestern Hawaiian Islands; approximately 138 in Main Hawaiian Islands	Endangered

> = greater than; CV = coefficient of variation; DPS = distinct population segment; ESA = Endangered Species Act; m = meters; N/A = not applicable
a Stock designations and abundance were obtained from Allen and Angliss (2014) and Carretta et al. (2015)
b The stated coefficient of variation (CV) is an indicator of uncertainty in the abundance estimate and describes the amount of variation with respect to the statistical population mean. It is expressed as a fraction or percentage and can range upward from zero (no uncertainty) to high values (greater uncertainty). For example, a CV of 0.8 would indicate much higher uncertainty than a CV of 0.2. When the CV reaches or exceeds 1.0, the estimate is highly uncertain, as the variation could be 100 percent or more of the estimated abundance. The uncertainty associated with movements of animals into or out of an area (due to factors such as prey availability or oceanographic conditions) is much larger than is indicated by the statistical CVs that are given.

Insular Pacific-Hawaiian Large Marine Ecosystem. The Central North Pacific stock of humpback whales occurs throughout known breeding grounds in the Hawaiian Islands during winter and spring (November through April) (Allen and Angliss, 2013). Peak occurrence is from late February through early April (Carretta et al., 2010; Mobley et al., 2000), with a peak in acoustic detections in March (Norris et al., 1999). A recent study that also used acoustic recordings near the Northwestern Hawaiian Islands indicates that humpback whales were present from early December through early June (Lammers et al., 2011). During the fall-winter period, primary occurrence is expected from the coast to 50 NM offshore (Mobley et al., 2000; Mobley, 2004). The greatest densities of humpback whales (including calves) are in the four-island region consisting of Maui, Molokai, Kahoolawe, and Lanai, as well as Penguin Bank (Mobley et al., 2000; Maldini et al., 2005) and around Kauai (Mobley, 2005). During the spring-summer period, secondary occurrence is expected offshore out to 50 NM. Occurrence farther offshore, or inshore (e.g., Pearl Harbor), has rarely been documented.

Survey results suggest that humpbacks may also be wintering in the Northwestern Hawaiian Island region and not just using it as a migratory corridor. A recent study that also used acoustic recordings near the Northwestern Hawaiian Islands indicates that humpback whales were present from early December through early June (Lammers et al., 2011). It is not yet known if this represents a previously undocumented breeding stock or if the whales occurring at the Northwestern Hawaiian Islands are part of the same population that winters near the Main Hawaiian Islands.

In breeding grounds, females with calves occur in significantly shallower waters than other groups of whales, and breeding adults use deeper more offshore waters (Smultea, 1994; Ersts and Rosenbaum, 2003). The habitat requirements of wintering humpbacks appear to be controlled by the conditions necessary for calving, such as warm water (75 to 80 ° Fahrenheit [F] [24° to 28° Celsius (C)]) and relatively shallow, low-relief ocean bottom in protected areas, created by islands or reefs (Smultea, 1994; Clapham, 2000; Craig and Herman, 2000).

Open Ocean. Most humpback whale sightings are in nearshore and continental shelf waters; however, humpback whales frequently travel through deep oceanic waters during migration (Calambokidis et al., 2001; Clapham and Mattila, 1990; Clapham, 2000). Humpback migrations are complex and cover long distances (Calambokidis, 2009; Barlow et al., 2011). Each year, most humpback whales migrate from high-latitude summer feeding grounds to low latitude winter breeding grounds, one of the longest migrations known for any mammal; individuals can travel nearly 4,970 miles (7,998.4 km) from feeding to breeding areas (Clapham and Mead, 1999). Humpback whales that breed in Hawaii generally migrate to northern British Columbia and southeast Alaska to feed. Animals breeding in Hawaii have also been "matched" (identified as the same individual) to humpbacks feeding in southern British Columbia and northern Washington (where matches were also found to animals breeding in Central America). Hawaii humpbacks are also known to feed in the Gulf of Alaska, the Aleutian Islands, and Bering Sea, where surprisingly matches were also found to animals that breed near islands off Mexico (Forestell and Urban-Ramirez, 2007; Barlow et al., 2011; Lagerquist et al., 2008) and between Japan and Hawaii (Salden et al., 1999). This study indicates that humpback whales migrating between Hawaii and British Columbia/southeast Alaska must cross paths with humpback whales migrating between the Gulf of Alaska/Aleutian Islands/Bering Sea and islands off Mexico. In addition, based on the identification of individual whales, there is evidence that some humpback whales (most likely males) move between winter breeding areas in Hawaii and Mexico (Forestall and Urban-Ramirez, 2007) and Hawaii and Japan (Salden et al., 1999).

Satellite tagging of humpback whales in the Hawaiian Islands found that one adult traveled 155 miles (249.4 km) to Oahu, Hawaii in 4 days, while a different individual traveled to Penguin Bank and five islands, totaling 530 miles (852.9 km) in 10 days. Both of these trips imply faster travel between the islands than had been previously recorded (Mate et al., 1998). Three whales traveled independent courses, following north and northeast headings toward the Gulf of Alaska, with the fastest averaging

93 miles (150 km) per day. At this rate, the animal would take an estimated 39 days to travel the entire 2,600 miles (4,200 km) migration route to the upper Gulf of Alaska (Mate et al., 1998).

Population and Abundance

The overall abundance of humpback whales in the north Pacific was recently estimated at 21,808 individuals (coefficient of variation = 0.04; this is an indicator of statistical uncertainty), confirming that this population of humpback whales has continued to increase and is now greater than some pre-whaling abundance estimates (Barlow et al., 2011). Data indicate the north Pacific population has been increasing at a rate of between 5.5 percent and 6.0 percent per year so approximately doubling every 10 years (Calambokidis et al., 2008). The Central North Pacific stock has been estimated at 10,103 individuals on wintering grounds throughout the Main Hawaiian Islands (Allen and Angliss, 2013). The Hawaiian Islands Humpback Whale National Marine Sanctuary reported in 2010 that over 50 percent of the entire North Pacific humpback whale population migrates to Hawaiian waters each year (NOAA, 2010). Based on aerial surveys conducted around the Main Hawaiian Islands, the number of humpback whales was estimated at 4,491 (Mobley et al., 2001b).

Predator/Prey Interactions

The most common invertebrate prey are krill (tiny crustaceans); the most common fish prey are herring, mackerel, sand lance, sardines, anchovies, and capelin (Clapham and Mead, 1999). Feeding occurs both at the surface and in deeper waters, wherever prey is abundant. Humpback whales are the only species of baleen whale that show strong evidence of cooperation when they feed in large groups (D'Vincent et al., 1985). It is believed that minimal feeding occurs in wintering grounds, such as the Hawaiian Islands (Balcomb, 1987; Salden, 1989). This species is known to be attacked by both killer whales and false killer whales as evidenced by tooth rake scars on their bodies and fins (Jefferson et al., 2015).

Species Specific Threats

Entanglement in fishing gear poses a threat to individual humpback whales throughout the Pacific. Humpback whales from the Central North Pacific stock have been reported seriously injured and killed from entanglement in fishing gear while in their Alaskan feeding grounds (Allen and Angliss, 2013). From 2003 to 2007, an average of 3.4 humpback whales per year were seriously injured or killed due to entanglements with commercial fishing gear in Alaskan waters. This number is considered a minimum since observers have not been assigned to several fisheries known to interact with this stock and quantitative data on Canadian fishery entanglements are uncertain (Allen and Angliss, 2013). In the Hawaiian Islands, there are also reports of humpback whale entanglements with fishing gear. Between 2002 and 2014, the Hawaiian Islands Disentanglement Network responded to 139 confirmed large whale entanglement reports (Hawaiian Islands Humpback Whale National Marine Sanctuary, 2014). All but three of the reports (a sei whale and two sperm whales) involved humpback whales. In the 2013-2014 season, at least 13 whales were reported as entangled, with fishing gear (crab trap and longline gear) confirmed in three of the events.

Humpback whales, especially calves and juveniles, are highly vulnerable to ship strikes. Younger whales spend more time at the surface, are less visible, and are found closer to shore (Herman et al., 1980; Mobley et al., 1999), thereby making them more susceptible to collisions. In their Alaskan feeding grounds, eight ship strikes were implicated in mortality or serious injuries of humpback whales between 2003 and 2007 and seven between 2006 and 2010 (Allen and Angliss, 2011; Allen and Angliss, 2013); when they migrate to and from Alaska, some of these whales spend time in Hawaii.

In the Hawaiian Islands, there were nine reported ship collisions with humpback whales in 2006 (none involved Navy vessels), as recorded by the NMFS Pacific Islands Region Marine Mammal Response Network Activity Updates (NMFS, 2007a). The number of confirmed ship strike reports was greater in 2007/2008; there were 12 reported ship-strikes with humpback whales: 9 reported as hit by vessels, and 3 observed with wounds indicating a recent ship strike (NMFS, 2008a). A humpback carcass was discovered on the shore of west Molokai in 2010 with indications that the death resulted from trauma consistent with a ship strike (NMFS, 2010e).

Humpback whales are potentially affected by loss of habitat, loss of prey, underwater noise, and pollutants. The Central North Pacific stock of humpback whales is the focus of whale-watching activities in both its feeding grounds (Alaska) and breeding grounds (Hawaii). Regulations addressing minimum approach distances and vessel operating procedures are in place to help protect the whales; however, there is still concern that whales may abandon preferred habitats if the disturbance is too high (Allen and Angliss, 2010).

3.1.2 Blue Whale (*Balaenoptera musculus*)

The world's population of blue whales can be separated into three subspecies, based on geographic location and some morphological differences. The true blue whales have been divided into two subspecies found in the northern hemisphere (*Balaenoptera musculus musculus*) and the southern hemisphere (*Balaenoptera musculus intermedia*). The third subspecies, the pygmy blue whale (*Balaenoptera musculus brevicauda*), is known to have overlapping ranges with both subspecies of true blue whales (Best et al., 2003; Reeves et al., 2002).

Status and Management

The blue whale is listed as endangered under the ESA and as depleted under the MMPA. For the MMPA stock assessment reports, the Central North Pacific Stock of blue whales includes animals found around the Hawaiian Islands during winter (Carretta et al., 2015).

Geographic Range and Distribution

General. The blue whale, the largest whale species, inhabits all oceans and typically occurs near the coast, over the continental shelf, though it is also found in oceanic waters. Their range includes the California Current and Insular Pacific-Hawaiian Large Marine Ecosystems, and the open ocean. Blue whales have been sighted, acoustically recorded, and satellite tagged in the eastern tropical Pacific (Ferguson, 2005; Stafford et al., 2004).

Insular Pacific-Hawaiian Large Marine Ecosystem. Blue whales are found seasonally in the Hawaii region, but sighting frequency is low. Whales feeding along the Aleutian Islands of Alaska likely migrate to offshore waters north of Hawaii in winter.

Open Ocean. Most blue whale sightings are in nearshore and continental shelf waters; however, blue whales frequently travel through deep oceanic waters during migration (Širović et al., 2004). Most baleen whales spend their summers feeding in productive waters near the higher latitudes and winters in the warmer waters at lower latitudes (Širović et al., 2004). Blue whales belonging to the western Pacific stock may feed in summer, south of the Aleutians and in the Gulf of Alaska, and migrate to wintering grounds in lower latitudes in the western Pacific and central Pacific, including Hawaii (Stafford et al., 2004; Watkins et al., 2000).

Population and Abundance

In the north Pacific, up to five distinct populations of blue whales are believed to occur, although only one stock is currently identified. The overall abundance of blue whales in the eastern tropical Pacific is estimated at 1,400 individuals. The most recent survey data indicate a summer/fall abundance estimate of 81 individuals (CV = 1.14) in the U.S. Exclusive Economic Zone (EEZ) off the coast of Hawaii (hereafter referred to as the Hawaiian Islands EEZ) (Carretta et al., 2015). This estimate could potentially be low, as the majority of blue whales would be expected to be at higher latitude feeding grounds at that time.

Predator/Prey Interactions

This species preys almost exclusively on various types of zooplankton, especially krill. Blue whales lunge feed and consume approximately 6 tons (5,500 kilograms) of krill per day (Jefferson et al., 2015, Pitman et al., 2007). They sometimes feed at depths greater than 330 feet (100 m), where their prey maintains dense groupings (Acevedo-Gutiérrez et al., 2002). Blue whales have been documented to be preyed on by killer whales (Jefferson et al., 2015; Pitman et al., 2007). There is little evidence that killer whales attack this species in the north Atlantic or southern hemisphere, but 25 percent of photo-identified whales in the Gulf of California carry rake scars from killer whale attacks (Sears and Perrin, 2008).

Species Specific Threats

Blue whales are considered to be susceptible to entanglement in fishing gear and ship strikes.

3.1.3 **Fin Whale (*Balaenoptera physalus*)**

Status and Management

The fin whale is listed as endangered under the ESA and as depleted under the MMPA. Pacific fin whale population structure is not well known. In the north Pacific, recognized stocks include the California/Oregon/Washington, Hawaii, and Northeast Pacific stocks (Carretta et al., 2015).

Geographic Range and Distribution

General. The fin whale is found in all the world's oceans and is the second largest species of whale (Jefferson et al., 2015). Fin whales prefer temperate and polar waters and are scarcely seen in warm, tropical waters (Reeves et al., 2002). Fin whales typically congregate in areas of high productivity. They spend most of their time in coastal and shelf waters, but can often be found in waters of approximately 6,562 feet (2,000 m) (Aissi et al., 2008; Reeves et al., 2002). Attracted for feeding, fin whales are often seen closer to shore after periodic patterns of upwelling and the resultant increased krill density (Azzellino et al., 2008). This species of whale is not known to have a specific habitat and is highly adaptable, following prey, typically off the continental shelf (Azzellino et al., 2008; Panigada et al., 2008). The range of the fin whale is known to include the Insular Pacific-Hawaiian Large Marine Ecosystems and the open ocean.

Insular Pacific-Hawaiian Large Marine Ecosystem. Fin whales are found in Hawaiian waters, but this species is considered to be rare in the area (Carretta et al., 2010; Shallenberger, 1981). There are known sightings from Kauai and Oahu, and a single stranding record from Maui (Mobley et al., 1996; Shallenberger, 1981; U.S. Department of the Navy, 2011). Summer/fall shipboard surveys of the Hawaiian Islands EEZ resulted in five sightings in 2002 and two sightings in 2010 (Barlow, 2003; Bradford et al., 2013). A single sighting was made during aerial surveys from 1993 to 1998 (Mobley et al., 1996; Mobley et al., 2000). The most recent sighting was a single juvenile fin whale reported off Kauai in 2011 (U.S. Department of the Navy, 2011). Based on sighting data and acoustic recordings, fin whales are likely to occur in Hawaiian waters mainly in fall and winter (Barlow et al., 2006; Barlow et al., 2008; Barlow et al., 2004).

Open Ocean. Fin whales have been recorded in the eastern tropical Pacific (Ferguson, 2005) and are frequently sighted there during offshore ship surveys. Fin whales are relatively abundant in north Pacific offshore waters, including areas off Hawaii (Berzin and Vladimirov, 1981; Mizroch et al., 2009). Locations of breeding and calving grounds for the fin whale are unknown, but it is known that the whales typically migrate seasonally to higher latitudes every year to feed and migrate to lower latitudes to breed (Kjeld et al., 2006; MacLeod et al., 2006b). The fin whale's ability to adapt to areas of high productivity controls migratory patterns (Canese et al., 2006; Reeves et al., 2002). Fin whales are one of the fastest cetaceans, capable of attaining speeds of 25 miles (40.2 km) per hour (Jefferson et al., 2015; Marini et al., 1996).

Population and Abundance

The best available abundance estimate for the Hawaii stock of fin whales is 58 (CV = 1.12). This could possibly be considered an underestimate because the majority of whales would be expected to have been at higher latitude feeding grounds at that time of the most recent summer/fall surveys (Carretta et al., 2015).

Predator/Prey Interactions

This species preys on small invertebrates such as copepods, squid, and schooling fishes such as capelin, herring, and mackerel (Goldbogen et al., 2006; Jefferson et al., 2015). The fin whale is not known to have a significant number of predators. However, in regions where killer whales are abundant, some fin whales exhibit attack scars on their flippers, flukes, and flanks suggesting possible predation by killer whales (Aguilar, 2008).

Species Specific Threats

Fin whales are susceptible to ship strikes and entanglement in fishing gear.

3.1.4 Sei Whale (*Balaenoptera borealis*)

The sei whale is a medium-sized rorqual falling in size between the fin whale and Bryde's whale and, given the difficulty of some field identifications and similarities in the general appearance of the three species, may sometimes be recorded in surveys as unidentified rorqual.

Status and Management

The sei whale is listed as endangered under the ESA and as depleted under the MMPA. A recovery plan for the sei whale was completed in 2011 and provides a research strategy for obtaining data required to estimate population abundance and trends, and to identify factors that may be limiting the recovery of this species (NMFS, 2011d). Although the International Whaling Commission recognizes one stock of sei whales in the north Pacific, some evidence indicates that more than one population exists. For the MMPA stock assessment reports, sei whales in the Pacific EEZ are divided into three areas: Hawaii, California/Oregon/Washington, and Alaska (Carretta et al., 2015).

Geographic Range and Distribution

General. Sei whales have a worldwide distribution and are found primarily in cold temperate to subpolar latitudes. During the winter, sei whales are found from 20° North (N) to 23° N and during the summer from 35° N to 50° N (Horwood, 2009; Masaki, 1976, 1977; Smultea et al., 2010). However, a recent survey of the Northern Mariana Islands recorded sei whales south of 20° N in the winter (Fulling et al., 2011). They are considered absent or at very low densities in most equatorial areas.

Insular Pacific-Hawaiian Large Marine Ecosystem. The first verified sei whale sighting made nearshore of the Main Hawaiian Islands occurred in 2007 (Smultea et al., 2007; Smultea et al., 2010) and included the first subadults seen in the Main Hawaiian islands. A line-transect survey conducted in February 2009 by the Cetacean Research Program surrounding the Hawaiian Islands resulted in three Bryde's/sei whale sightings. An additional sighting occurred in 2010 (U.S. Department of Navy, 2011). In March 2011 off Maui, the Hawaiian Islands Entanglement Response Network found a subadult sei whale entangled in rope and fishing gear (NMFS, 2011c). An attempt to disentangle the whale was unsuccessful although a telemetry buoy attached to the entangled gear was reported to be tracking the whale over 21 days as it moved north and over 250 NM from the Hawaiian Islands.

The sei whale has been considered rare in the Hawaii region based on reported sighting data and the species' preference for cool temperate waters. Sei whales were not sighted during aerial surveys conducted within 25 NM of the Main Hawaiian Islands from 1993 to 1998 (Mobley et al., 2000). Based on sightings made during the NMFS-Southwest Fisheries Science Center shipboard survey assessment of Hawaiian cetaceans (Barlow et al., 2004), sei whales were expected to occur in deep waters on the north side of the islands only. However, in 2007 two sei whale sightings occurred north of Oahu, Hawaii during a short survey in November and these included three subadult whales. These latter sightings suggest that the area north of the Main Hawaiian Islands may be part of a reproductive area for north Pacific sei whales (Smultea et al., 2010). Summer/fall shipboard surveys of the Hawaiian Islands EEZ resulted in four sightings in 2002 and three in 2010 (Barlow, 2003; Bradford et al., 2013).

Open Ocean. Sei whales are most often found in deep oceanic waters of the cool temperate zone. They appear to prefer regions of steep bathymetric relief, such as the continental shelf break, canyons, or basins between banks and ledges (Best and Lockyer, 2002; Gregr and Trites, 2001; Kenney and Winn, 1987; Schilling et al., 1992). On feeding grounds, the distribution is largely associated with oceanic frontal systems (Horwood, 1987). Characteristics of preferred breeding grounds are unknown, since they have generally not been identified.

Sei whales spend the summer feeding in high latitude subpolar latitudes and return to lower latitudes to calve in winter. Whaling data provide some evidence of differential migration patterns by reproductive class, with females arriving at and departing from feeding areas earlier than males (Horwood, 1987; Perry et al., 1999). Sei whales are known to swim at speeds greater than 15 miles (25 km) per hour and may be the second fastest cetacean, after the fin whale (Horwood, 2009; Jefferson et al., 2015).

Population and Abundance

The best current estimate of abundance for the Hawaii stock of sei whales is 178 animals (CV = 0.90). This abundance estimate is considered the best available estimate for the Hawaiian Islands EEZ, but may be an underestimate, as sei whales are expected to have been mostly at higher latitudes on their feeding grounds during the time of year of the most recent surveys (summer/fall). No data are available on current population trends.

Predator/Prey Interactions

In the north Pacific, sei whales feed on a diversity of prey, including copepods, krill, fish (specifically sardines and anchovies), and cephalopods (squids, cuttlefish, octopuses) (Horwood, 2009; Nemoto and Kawamura, 1977). Feeding occurs primarily around dawn, which appears to be correlated with vertical migrations of prey species (Horwood, 2009). Unlike other rorquals, the sei whale skims to obtain its food, although, like other rorqual species, it does some lunging and gulping (Horwood, 2009).

Sei whales, like other large baleen whales, are likely subject to occasional attacks by killer whales.

Species Specific Threats

Based on the statistics for other large whales, it is likely that ship strikes also pose a threat to sei whales.

3.1.5 Sperm Whale (*Physeter macrocephalus*)

The sperm whale is the only large whale that is an odontocete (toothed whale).

Status and Management

The sperm whale has been listed as endangered since 1970 under the precursor to the ESA, and is depleted under the MMPA. Sperm whales are divided into three stocks in the Pacific. Of these, the Hawaii stock occurs within the Study Area.

Geographic Range and Distribution

General. The sperm whale occurs in all oceans, ranging from the pack ice in both hemispheres to the equator. Primarily, this species is typically found in the temperate and tropical waters of the Pacific (Rice, 1989). This species appears to have a preference for deep waters (Jefferson et al., 2015). Typically, sperm whale concentrations correlate with areas of high productivity, including areas near drop offs and with strong currents and steep topography (Gannier and Praca, 2007; Jefferson et al., 2015).

Insular Pacific-Hawaiian Large Marine Ecosystem. Sperm whales occur in Hawaii waters and are one of the more abundant large whales found in the region (Baird et al., 2003b; Mobley et al., 2000).

Open Ocean. Sperm whales show a strong preference for deep waters (Rice, 1989; Whitehead, 2003). Their distribution is typically associated with waters over the continental shelf break, over the continental slope, and into deeper waters.

Sperm whales are somewhat migratory. General shifts occur during summer months for feeding and breeding, while in some tropical areas, sperm whales appear to be largely resident (Rice, 1989; Whitehead, 2003; Whitehead et al., 2008). Pods of females with calves remain on breeding grounds throughout the year, between 40° N and 45° N (Rice, 1989; Whitehead, 2003), while males migrate between low-latitude breeding areas and higher-latitude feeding grounds (Pierce et al., 2007). In the northern hemisphere, "bachelor" groups (males typically 15 to 21 years old and bulls [males] not taking part in reproduction) generally leave warm waters at the beginning of summer and migrate to feeding grounds that may extend as far north as the perimeter of the arctic zone. In fall and winter, most return south, although some may remain in the colder northern waters during most of the year (Pierce et al., 2007).

Population and Abundance

The abundance of sperm whales in the eastern tropical Pacific has been estimated as 22,700 individuals. The current best available abundance estimate for the Hawaii stock of sperm whales is 3,354 (CV = 0.34). Sperm whales are frequently identified via visual observation and hydrophones on the PMRF range (Department of the Navy, 2015).

Predator/Prey Interactions

Sperm whales are known to occur in groups for both predator defense and foraging purposes. Sperm whales feed on squid, other cephalopods, and bottom-dwelling fish and invertebrates (Davis et al., 2007; Marcoux et al., 2007; Rice, 1989). Exactly how sperm whales search for, detect, and capture their prey remains uncertain. False killer whales, pilot whales, and killer whales have been documented harassing and on occasion attacking sperm whales (Baird, 2009a).

Species Specific Threats

Sperm whales are susceptible to entanglement in fishing gear, ingestion of marine debris, and ship strikes.

3.1.6 False Killer Whale (*Pseudorca crassidens*)

Status and Management

Not much is known about most false killer whale populations globally, but the species is known to be present in Hawaiian waters. NMFS currently recognizes a Hawaiian Islands Stock Complex, which includes the Hawaii Pelagic stock, the Northwestern Hawaiian Islands stock, and the Main Hawaiian Islands insular stock. All stocks of false killer whales are protected under the MMPA. The Main Hawaiian Islands insular stock (considered resident to the Main Hawaiian Islands consisting of Kauai, Oahu, Molokai, Lanai, Kahoolawe, Maui, and Hawaii) is listed as endangered under the ESA and as depleted under the MMPA. The historic decline of this stock has been the result of various factors including small population size, evidence of decline of the local Hawaii stock, and incidental take by commercial fisheries (Oleson et al., 2010). It is estimated that approximately eight false killer whales from the Main Hawaiian Islands insular and Hawaii Pelagic stocks are killed or seriously injured by commercial longline fisheries each year (McCracken and Forney, 2010). This number is most likely an underestimate since it does not include any animals that were unidentified and might have been false killer whales. Due to evidence of a serious decline in the population (Reeves et al., 2009), a Take Reduction Team (a team of experts to study the specific topic, also referred to as a Biological Reduction Team) was formed by NOAA in 2010 as required by the MMPA. As a result of the Take Reduction Team's activities, a Take Reduction Plan was published in 2012. The Plan identifies regulatory and non-regulatory measures designed to reduce mortalities and serious injuries of false killer whales that are associated with Hawaii long-line fisheries.

The NMFS considers all false killer whales found within 72 km (39 NM) of each of the Main Hawaiian Islands as part of the Main Hawaiian Islands Insular stock. In the vicinity of the Main Hawaiian Islands, the Hawaii Pelagic stock is considered to inhabit waters greater than 11 km (6 NM) from shore. There is no inner boundary for the Hawaii Pelagic stock within the Northwestern Hawaiian Islands. Animals belonging to the Northwestern Hawaiian Islands stock are considered to inhabit waters within a 93 km (50 NM) radius of the Northwestern Hawaiian Islands, or the boundary of the Papahānaumokuākea Marine National Monument, with the radial boundary extended to the southeast to encompass Kauai and Niihau. NMFS recognizes that there is geographic overlap between the stocks in some areas. In particular, individuals from the Northwestern Hawaiian Islands and Hawaii Pelagic stocks have potential for occurrence at the Long Range Strike WSEP impact location. This overlap precludes analysis of differential impact between the two stocks based on spatial criteria.

The density data used in the Navy's modeling and analyses were derived from habitat-based density models for the combined stocks, since limited sighting data did not allow for stock-specific models (Becker et al., 2012). Habitat-based density models allow predictions of cetacean densities on a finer spatial scale than traditional analyses (Barlow et al., 2009) and are thus better suited for spatially explicit effects analyses. In the most recent draft stock assessment report (Carretta et al., 2015), separate abundance numbers are provided for each stock of the false killer whale Hawaiian Islands Stock Complex.

Geographic Range and Distribution

General. The range of this species is known to include waters of the Insular Pacific-Hawaiian Large Marine Ecosystems and the North Pacific Gyre.

Insular Pacific-Hawaiian Large Marine Ecosystem. The false killer whale is regularly found within Hawaiian waters and has been reported in groups of up to 100 (Shallenberger, 1981; Baird et al., 2003a). A handful of stranding records exists in the Hawaiian Islands (Maldini et al., 2005). Distribution of Main Hawaiian Islands insular false killer whales has been assessed using data from visual surveys and satellite tag data. Tagging data from seven groups of individuals tagged off the islands of Hawaii and Oahu indicate that the whales move rapidly and semi-regularly throughout the Main Hawaiian Islands and have been documented as far as 112 km offshore over a total range of 31,969 square miles (mi^2) (82,800 square kilometers [km^2]) (Baird et al., 2012). Baird et al. (2012) note, however, that limitations in the sampling "suggest the range of the population is likely underestimated, and there are probably other high-use areas that have not been identified." Photo identification studies also document that the animals regularly use both leeward and windward sides of the islands (Baird et al., 2005a; Baird, 2009a; Baird et al., 2010b; Forney et al., 2010; Baird et al., 2012). Some individual false killer whales tagged off the island of Hawaii have remained around that island for extended periods (days to weeks), but individuals from all tagged groups eventually were found broadly distributed throughout the Main Hawaiian Islands (Baird, 2009a; Forney et al., 2010). Individuals utilize habitat over varying water depths from less than 164 feet (50 m) to greater than 13,123 feet (4,000 m) (Baird et al., 2010b). It has been hypothesized that inter-island movements may depend on the density and movement patterns of their prey species (Baird, 2009a).

Open Ocean. In the north Pacific, this species is known to occur in deep oceanic waters off Hawaii and elsewhere in the Pacific (Carretta et al., 2010; Miyashita et al., 1996; Wang et al., 2001). False killer whales are not considered a migratory species, although seasonal shifts in density likely occur. Seasonal movements in the western north Pacific may be related to prey distribution (Odell and McClune, 1999). Satellite-tracked individuals around the Hawaiian Islands indicate that false killer whales can move extensively among different islands and also sometimes move from an island coast to as far as 60 miles. (96.6 km) offshore (Baird, 2009a; Baird et al., 2010b).

Population and Abundance

False killer whales found in waters surrounding the Main Hawaiian Islands are known to be genetically separate from the population in the outer part of the Hawaiian Islands EEZ and the central tropical Pacific (Chivers et al., 2007; Reeves et al., 2009). Recent genetic research by Chivers et al. (2010) indicates that the Main Hawaiian Islands insular and Hawaii Pelagic populations of false killer whales are independent and do not interbreed. The current abundance estimate of the Main Hawaiian Islands insular stock is 151 individuals (CV = 0.20), the Hawaii Pelagic stock is 1,540 individuals (CV = 0.66), and the Northwestern Hawaiian Islands stock is 617 individuals (CV = 1.11).

Reeves et al. (2009) summarized information on false killer whale sightings near Hawaii between 1989 and 2007, based on various survey methods, and suggested that the Main Hawaiian Islands stock may have declined during the last two decades. Baird (2009a) reviewed trends in sighting rates of false killer whales from aerial surveys conducted using consistent methodology around the Main Hawaiian Islands between 1994 and 2003. Sighting rates during these surveys exhibited a significant decline that could not be attributed to any weather or methodological changes. Data are currently insufficient to determine population trends for the Northwestern Hawaiian Islands or Hawaii Pelagic stocks (Carretta et al., 2015).

Predator/Prey Interactions

False killer whales feed primarily on deep-sea cephalopods and fish (Odell and McClune, 1999). They may prefer large fish species, such as mahi mahi and tunas. Twenty-five false killer whales that stranded off the coast of the Strait of Magellan were examined and found to feed primarily on cephalopods and fish. Squid beaks were found in nearly half of the stranded animals. The most important prey species were found to be the squid species, *Martialiabyadesi* and *Illex argentinus,* followed by the coastal fish, *Macruronus magellanicus* (Alonso et al., 1999). False killer whales have been observed to attack other cetaceans, including dolphins and large whales such as humpback and sperm whales (Baird, 2009b). They are known to behave aggressively toward small cetaceans in tuna purse seine nets. Unlike other whales or dolphins, false killer whales frequently pass prey back and forth among individuals before they start to eat the fish, in what appears to be a way of affirming social bonds (Baird et al., 2010b). This species is believed to be preyed on by large sharks and killer whales (Baird, 2009b). Like many marine mammals, false killer whales accumulate high levels of toxins in their blubber over the course of their long lives. Because they feed on large prey at the top of the food chain (e.g., squid, tunas) they may be impacted by competition with fisheries (Cascadia Research, 2010).

Species Specific Threats

In Hawaiian waters, false killer whales are particularly susceptible to fishery interactions and entanglements (Forney et al., 2010).

3.1.7 **Hawaiian Monk Seal (*Neomonachus schauinslandi*)**

Status and Management

The Hawaiian monk seal is listed as endangered under the ESA. The species is considered a high priority for recovery, based on the high magnitude of threats, the high recovery potential, and the potential for economic conflicts while implementing recovery actions (NMFS, 2007d). Hawaiian monk seals are managed as a single stock. NMFS has identified reproductive subpopulations at French Frigate Shoals, Laysan Island, Lisianski Island, Pearl and Hermes Reef, Midway Atoll, Kure Atoll, and Necker and Nihoa Islands in the Northwestern Hawaiian Islands (NMFS, 2014). The species also occurs throughout the Main Hawaiian Islands (e.g., there is a population of approximately 200 individuals in the Main Hawaiian Islands [NMFS, 2016] and the total population is estimated to be fewer than 1,200 individuals). The approximate area encompassed by the Northwestern Hawaiian Islands was designated as the Papahānaumokuākea Marine National Monument in 2006.

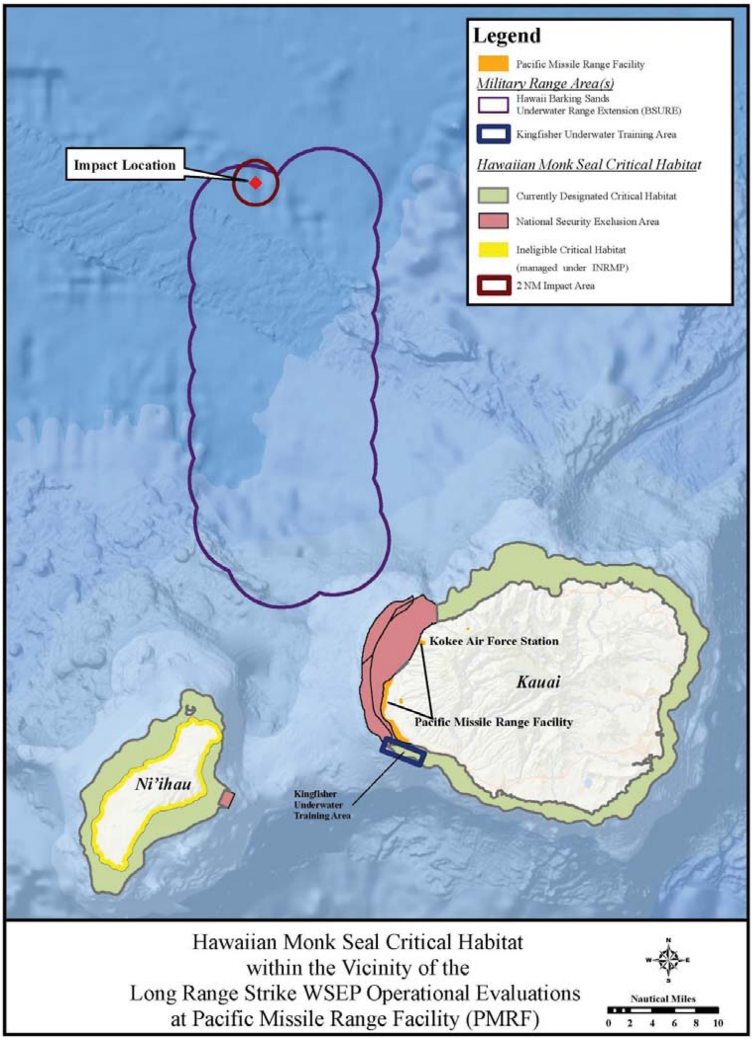
A recovery plan for the Hawaiian monk seal was completed in 1983 and was revised in 2007 (NMFS, 2007d). In 1986, critical habitat was designated for all beach areas, sand spits and islets, lagoon waters, inner reef waters, and ocean waters to a depth of 10 fathoms (18.3 m) around Kure Atoll, Midway Islands (except Sand Island), Pearl and Hermes Reef, Lisianski Island, Laysan Island, Gardner Pinnacles, French Frigate Shoals, Necker Island, and Nihoa Island in the Northwestern Hawaiian Islands (NMFS, 1986). In 1988, the critical habitat was extended to include Maro Reef and waters around previously recommended areas out to the 20 fathom (36.6 m) isobath (NMFS, 1988). In order to reduce the probability of direct interaction between Hawaiian-based long-line fisheries and monk seals, a Protected Species Zone was put into place in the Northwestern Hawaiian Islands, prohibiting long-line fishing in this zone. In 2000, the waters from 3 to 50 NM around the Northwestern Hawaiian Islands were designated the Northwestern Hawaiian Islands Coral Reef Ecosystem Reserve, and specific restrictions were placed on human activities there (Antonelis et al., 2006).

In 2008, NMFS received a petition requesting that the critical habitat in the Northwestern Hawaiian Islands be expanded to include Sand Island at Midway and ocean waters out to a depth of 500 m and that the following critical habitat be added in the Main Hawaiian Islands: key beach areas, sand spits and islets, lagoon waters, inner reef waters, and ocean waters to a depth of 200 m. In 2009, NMFS announced a 12-month finding indicating the intention to revise critical habitat, and in 2011 NMFS proposed that critical habitat in the Northwestern Hawaiian Islands be expanded to include Sand Island at Midway and ocean waters out to a depth of 500 m and that six new extensive areas in the Main Hawaiian Islands be added. In August 2015, NMFS published a final rule revising critical habitat designation to include 10 areas in the Northwestern Hawaiian Islands and 6 areas in the Main Hawaiian Islands (50 CFR Part 226, 21 August 2015). NMFS excluded several areas from designation because either (1) the national security benefits of exclusion outweigh the benefits of inclusion (and exclusion will not result in extinction of the species), or (2) they are managed under Integrated Natural Resource Management Plans that provide a benefit to the species (these areas are termed “ineligible”). Critical Habitat Specific Area 13 includes portions of the Kauai coastline and associated marine waters. However, portions of the PMRF were excluded, including the PMRF Main Base at Barking Sands and the PMRF Offshore Areas in marine areas off the western coast of Kauai. Hawaiian monk seal critical habitat is shown in Figure 3-1.

The Pacific Island Regional Office of NMFS has the lead responsibility for the recovery of Hawaiian monk seals under the ESA and the MMPA. Since the early 1980s, NMFS has routinely applied flipper tags to weaned pups in the Northwestern Hawaiian Islands (Antonelis et al., 2006). NMFS performed capture and release programs through the Head Start Program between 1981 and 1991, “to enhance the survival of young females and thereby increase their subsequent recruitment into the adult female population.” From 1984 to 1995, under NMFS’s Rehabilitation Project, undersized, weaned female pups from French Frigate Shoals and, in some cases, undersized juvenile females, were brought into captivity for 8 to 10 months on Oahu to increase their weight. They were then released into the wild at either Kure Atoll or Midway Islands, where they had a higher probability of survival (Antonelis et al., 2006). Because some males were injuring female seals, in July and August of 1994, 21 adult male Hawaiian monk seals were relocated from Laysan Island to the Main Hawaiian Islands (NMFS, 2009a). NMFS has relocated three female monk seals (a juvenile in 1981, a pup in 1991, and an adult in 2009) from the Main Hawaiian Islands to the Northwestern Hawaiian Islands (NMFS, 2009a).

Other agencies that also play an important role in the Northwestern Hawaiian Islands are the Marine Mammal Commission, the USFWS, which manages wildlife habitat and human activities within the lands and waters of the Hawaiian Islands National Wildlife Refuge and the Midway Atoll National Wildlife Refuge; the U.S. Coast Guard, which assists with enforcement and efforts to clean up marine pollution; the National Ocean Service, which conserves natural resources in the Northwestern Hawaiian Islands Coral Reef Ecosystem Reserve; and the Western Pacific Regional Fishery Management Council, which develops fishery management plans and proposes regulations to NMFS for commercial fisheries around the Northwestern Hawaiian Islands (Marine Mammal Commission, 2002).

Figure 3-1. Critical Habitat of the Hawaiian Monk Seal near the Study Area



The State of Hawaii also has important responsibilities for monk seal conservation and recovery. It owns Kure Atoll and has jurisdiction over waters between the reserve boundary and 3 NM around all emergent lands in the Northwestern Hawaiian Islands (except Midway) (Marine Mammal Commission, 2002). In March 2007, the State of Hawaii put new regulations into place to restrict the use of lay nets on Oahu, Molokai, Lanai, Kauai, and Niihau and prohibited lay net use in state waters around the entire island of Maui and certain areas on Oahu (NMFS, 2010c). In 2008, in hopes of raising awareness of the species, Hawaii's Lieutenant Governor signed into law legislation that established the Hawaiian monk seal as the official state mammal.

When seals are reported on beaches in the main islands, NMFS works with state and local agencies to cordon off sections of beach around the seals. NMFS also relies on volunteer groups to observe seals and educate the public about their endangered status and protection measures. On Oahu, the Hawaiian Monk Seal Response Team Oahu is a team of over 50 volunteers who routinely assist NOAA Fisheries Pacific Island Regional Office and the Pacific Island Fisheries Science Center in monk seal response issues. Monk seal response programs also exist on Kauai, Maui and the Island of Hawaii, with some reporting from Molokai and Lanai (NMFS, 2010c).

There is also a multiagency marine debris working group that was established in 1998 to remove derelict fishing gear, which has been identified as a top threat to this species, from the Northwestern Hawaiian Islands (Donohue and Foley, 2007). Agencies involved in these efforts include The Ocean Conservancy, the City and County of Honolulu, the Coast Guard, the USFWS, the Hawaii Wildlife Fund, the Hawaii Sea Grant Program, the National Fish and Wildlife Foundation, the Navy, the University of Alaska Marine Advisory Program, and numerous other state and private agencies and groups (Marine Mammal Commission, 2002).

The Navy has previously funded some monk seal tagging projects conducted by Pacific Islands Fisheries Science Center personnel. In addition, since 2013, some collaborative projects have been undertaken under the PMRF Integrated Natural Resources Management Plan.

Geographic Range and Distribution

General. Monk seals can rapidly cover large areas in search of food and may travel hundreds of miles in a few days (Littnan et al., 2007).

Insular Pacific-Hawaiian Large Marine Ecosystem. The Hawaiian monk seal is the only endangered marine mammal whose range is entirely within the United States (NMFS, 2007d). Hawaiian monk seals can be found throughout the Hawaiian Island chain in the Insular Pacific-Hawaiian Large Marine Ecosystem. Sightings have also occasionally been reported on nearby island groups south of the Hawaiian Island chain, such as Johnston Atoll, Wake Island, and Palmyra Atoll (Carretta et al., 2010; Gilmartin and Forcada, 2009; Jefferson et al., 2015; NMFS, 2009a). The main breeding sites are in the Northwestern Hawaiian Islands: French Frigate Shoals, Laysan Island, Lisianski Island, Pearl and Hermes Reef, Midway Atoll, Kure Atoll, and Necker and Nihoa Islands. Monk seals have also been observed at Gardner Pinnacles and Maro Reef. A small breeding population of monk seals is found throughout the Main Hawaiian Islands, where births have been documented on most of the major islands, especially Kauai (Gilmartin and Forcada, 2009; NMFS, 2007d; NMFS, 2010b). It is possible that, before Western contact, Polynesians destroyed the Hawaiian monk seals from the Main Hawaiian Islands and that the seals were driven to less desirable habitat in the Northwestern Hawaiian Islands (Baker and Johanos, 2004).

Although the Hawaiian monk seal is found primarily on the Northwestern Hawaiian Islands (NMFS, 2014), sightings on the Main Hawaiian Islands have become more common (Johanos et al., 2015). During Navy-funded marine mammal surveys from 2007 to 2012, there were 41 sightings of Hawaiian monk seals, with a total of 58 individuals on or near Kauai, Kaula, Niihau, Oahu, and Molokai (HDR, 2012). Forty-seven (81 percent) individuals were seen during aerial surveys, and eleven (19 percent) during vessel surveys. Monk seals were most frequently observed at Niihau.

Monk seals spend most of their time at sea in nearshore, shallow marine habitats (Littnan et al., 2007). When hauled out, Hawaiian monk seals seem to prefer beaches of sand, coral rubble, and rocky terraces (Baker et al., 2006; Jefferson et al., 2015).

Climate models predict that global average sea levels may rise this century, potentially affecting species that rely on the coastal habitat. Topographic models of the low-lying Northwestern Hawaiian Islands were created to evaluate potential effects of sea level rise by 2100. Monk seals, which require the islands for resting, molting, and nursing, may experience more crowding and competition if islands shrink (Baker et al., 2006).

Based on one study, on average, 10 to 15 percent of the monk seals migrate among the Northwestern Hawaiian Islands and the Main Hawaiian Islands (Carretta et al., 2010). Another source suggests that 35.6 percent of the Main Hawaiian Island seals travel between islands throughout the year (Littnan, 2011).

Population and Abundance

Currently, the best estimate for the total population of monk seals is 1,153. Population dynamics at the different locations in the Northwestern Hawaiian Islands and the Main Hawaiian Islands has varied considerably (Antonelis et al., 2006). A population model for the years 2003–2012 suggests a decline in overall population of about 3.3 percent. However, the Main Hawaiian Islands population appears to be increasing, possibly at a rate of about 7 percent per year (NMFS, 2014). In the Main Hawaiian Islands, a minimum abundance of 45 seals was found in 2000, and this increased to 52 in 2001 (Baker, 2004). In 2009, 113 individual seals were identified in the Main Hawaiian Islands based on flipper tag ID numbers or unique natural markings. The total number in the Main Hawaiian Islands is currently estimated to be about 200 animals (NMFS, 2016). Beach counts in the Northwestern Hawaiian Islands since the late 1950s have shown varied population trends at specific times, but in general, abundance is low at most islands (NMFS, 2014).

Possible links between the spatial distribution of primary productivity in the Northwestern Hawaiian Islands and trends of Hawaiian monk seal abundance have been assessed for the past 40-plus years. Results demonstrate that monk seal abundance trends appear to be affected by the quality of local environmental conditions (including sea surface temperature, vertical water column structure, and integrated chlorophyll) (Schmelzer, 2000). Limited prey availability may be restricting the recovery of the Northwestern Hawaiian Islands monk seals (Baker, 2008; Brillinger et al., 2006; Carretta et al., 2010). Studies performed on pup survival rate in the Northwestern Hawaiian Islands between 1995 and 2004 showed severe fluctuations between 40 percent and 80 percent survival in the first year of life. Survival rates between 2004 and 2008 showed an increase at Lisianski Island and Pearl, Hermes, Midway, and Kure Atoll and a decrease at French Frigate Shoals and Laysan Island. Larger females have a higher survival rate than males and smaller females (Baker, 2008).

Estimated chances of survival from weaning to age one are higher in the Main Hawaiian Islands (77 percent) than in the Northwestern Hawaiian Islands (42 to 57 percent) (Littnan, 2011). The estimated Main Hawaiian Islands intrinsic rate of population growth is greater as well. If current trends continue, abundance in the Main Hawaiian Islands could eventually exceed that of the Northwestern Hawaiian Islands (NMFS, 2014). There are a number of possible reasons why pups in the Main Hawaiian Islands are faring better. One is that the per capita availability of prey may be higher in the Main Hawaiian Islands, due to the low monk seal population (Baker and Johanos, 2004). Another may have to do with the structure of the marine communities. In the Main Hawaiian Islands, the seals have less competition with other top predators, like large sharks, jacks, and other fish, which may enhance their foraging success (Baker and Johanos, 2004; Parrish et al., 2008).

A third factor may be the limited amount of suitable foraging habitat in the Northwestern Hawaiian Islands (Stewart et al., 2006). While foraging conditions are better in the Main Hawaiian Islands than in the Northwestern Hawaiian Islands, health hazards from exposure to pollutants and infectious disease agents associated with terrestrial animals pose risks not found in the Northwestern Hawaiian Islands (Littnan et al., 2007). Despite these risks, a self-sustaining subpopulation in the Main Hawaiian Islands could improve the monk seal's long-term prospects for recovery (Baker and Johanos, 2004; Carretta et al., 2005; Marine Mammal Commission, 2003).

Predator/Prey Interactions

The Hawaiian monk seal is a foraging generalist, often moving rocks to capture prey underneath (NMFS, 2014). Monk seals feed on many species of fish, cephalopods, and crustaceans. Prey species include representatives of at least 31 bony fish families, 13 cephalopod (octopus, squid, and related species) families, and numerous crustaceans (e.g., crab and lobster). Foraging typically occurs on the seafloor from the shallows to water depths of over 500 m. Data from tagged individuals indicate foraging occurs primarily in areas of high bathymetric relief within 40 km (25 miles) of atolls or islands, although submerged banks and reefs located over 300 km from breeding sites may also be used (NMFS, 2014). In general, seals associated with the Main Hawaiian Islands appear to have smaller home ranges, travel shorter distances to feed, and spend less time foraging than seals associated with the Northwestern Hawaiian Islands. The inner reef waters next to the islands are critical to weaned pups learning to feed; pups move laterally along the shoreline, but do not appear to travel far from shore during the first few months after weaning (Gilmartin and Forcada, 2009). Feeding has been observed in reef caves, as well as on fish hiding among coral formations (Parrish et al., 2000). A recent study showed that this species is often accompanied by large predatory fish, such as jacks, sharks, and snappers, which possibly steal or compete for prey that the monk seals flush with their probing, digging and rock-flipping behavior. The juvenile monk seals may not be of sufficient size or weight to get prey back once it has been stolen. This was noted only in the French Frigate Shoals (Parrish et al., 2008).

Monk seals and are known to be preyed on by both killer whales and sharks. Shark predation is one of the major sources of mortality for this species especially in the Northwestern Hawaiian Islands. Galapagos sharks are a large source of juvenile mortality in the Northwestern Hawaiian Islands, with most predation occurring in the French Frigate Shoals (Antonelis et al., 2006; Gilmartin and Forcada, 2009; Jefferson et al., 2015).

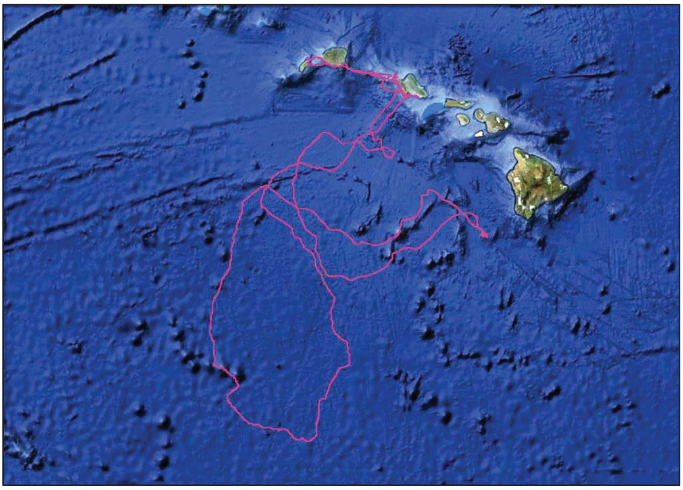
In an effort to better understand the habitat needs of foraging monk seals, Stewart et al. (2006) used satellite-linked radio transmitters to document the geographic and vertical foraging patterns of 147 Hawaiian monk seals from all six Northwestern Hawaiian Islands breeding colonies, from 1996 through 2002. Geographic patterns of foraging were complex and varied among colonies by season, age, and sex, but some general patterns were evident. Seals were found to forage extensively within barrier reefs of the atolls and on the leeward slopes of reefs and islands at all colony sites. They also ranged away from these sites along the Hawaiian Islands submarine ridge to most nearby seamounts and submerged reefs and banks (Stewart et al., 2006).

In 2005, 11 juvenile and adult monk seals were tracked in the Main Hawaiian Islands using satellite-linked radio transmitters showing location, but not depth (Littnan et al., 2007). Similar to the Northwestern Hawaiian Islands, monk seals showed a high degree of individual variability. Overall results showed most foraging trips to last from a few days to one to two weeks, with seals remaining within the 200-m isobaths surrounding the Main Hawaiian Islands and nearby banks (Littnan et al., 2007).

NMFS and the Navy have also monitored monk seals with cell phone tags (Littnan, 2011; Reuland, 2010). Results from one individual monk seal (R012) indicated travel of much greater distances and water depths than previously documented (Littnan, 2011). The track of this monk seal extended as much as 470 miles (756.4 km) from shore and a total distance of approximately 2,000 miles (3,218.7 km) where the ocean is over 5,000 m (16,404 feet) in depth (Figure 3-2). However, the distance traveled by this individual was substantially greater than that of foraging trips undertaken by other seals in the study, and may not represent typical behavior (Littnan, 2012).

Figure 3-2. Track of Hawaiian Monk Seal R012 in June 2010

Source: NOAA Fisheries, 2015



Species Specific Threats

Monk seals are particularly susceptible to fishery interactions and entanglements. In the Northwestern Hawaiian Islands, derelict fishing gear has been identified as a top threat to the monk seal (Donohue and Foley, 2007), while in the Main Hawaiian Islands, high risks are associated with health hazards from exposure to pollutants and infectious disease agents associated with terrestrial animals. Limited prey availability may be restricting the recovery of the Northwestern Hawaiian Islands monk seals (Baker, 2008; Brillinger et al., 2006; Carretta et al., 2010). Since they rely on coastal habitats for survival, monk seals may be affected by future sea level rise and loss of habitat as predicted by global climate models. Another species-specific threat includes aggressive male monk seals that have been documented to injure and sometimes kill females and pups (NMFS, 2010c). Other threats include reduced prey availability, shark predation, disease and parasites, and contaminants (NMFS, 2014).

3.2 Sea Turtles

This section provides a description of sea turtles that are potentially found in the BSURE area. The status of sea turtle populations is determined primarily from assessments of the adult female nesting populations. Much less is known about other life stages of these species (Mrosovsky et al., 2009; Schofield et al., 2010; Witt et al., 2010). The National Research Council (2010) recently reviewed the current state of sea turtle research, and concluded that relying too much on nesting beach data limits a more complete understanding of sea turtles and the evaluation of management options for their overall health and recovery. Five sea turtle species are potentially found in the Study Area, and all are listed under the ESA as endangered or threatened (see Table 1-1 in Section 1.3).

Sea turtles are highly migratory, and are present in coastal and open ocean waters of the Study Area. Most sea turtles prefer to live in warm waters because they are cold-blooded reptiles. Leatherbacks are the exception and are more likely to be found in colder waters at higher latitudes because of their unique ability to maintain an internal body temperature higher than that of the environment (Dutton, 2006). Habitat use varies among species and within the life stages of individual species, correlating primarily with the distribution of preferred food sources, as well as the locations of nesting beaches.

Habitat and distribution vary among species and life stages, and are discussed further in the species profiles below. Little information is available about sea turtles' stage of life after hatching. Open-ocean juveniles spend an estimated 2 to 14 years drifting, foraging, and developing. Because of the general lack of knowledge of this period, it has been described as "the lost years." After this period, juvenile hawksbill (*Eretmochelys imbricata*), olive ridley, loggerhead, and green turtles settle into coastal habitat, with individuals often remaining associated with a specific home range until adulthood (Bjorndal and Bolten, 1988; NMFS and USFWS, 1991). Leatherback turtles remain primarily in the open ocean throughout their lives, except for mating in coastal waters and females going ashore to lay eggs. All species can migrate long distances across large expanses of the open ocean, primarily between nesting and feeding grounds (NMFS and USFWS, 2007c).

All sea turtle species are believed to use a variety of orientation mechanisms on land and at sea (Lohmann et al., 1997). After emerging from the nest, hatchling turtles use visual cues, such as light wavelengths and shape patterns, to find the ocean (Lohmann et al., 1997). Once in the ocean, hatchlings use wave cues to navigate offshore (Lohmann and Lohmann, 1992). In the open ocean, turtles in all life stages are thought to orient to the earth's magnetic field to position themselves in oceanic currents; this helps them locate seasonal feeding and breeding grounds and return to their nesting sites (Lohmann and Lohmann, 1996; Lohmann et al., 1997). The stimuli that help sea turtles find their nesting beaches are still poorly understood, particularly the fine-scale navigation that occurs as turtles approach the site, and could also include chemical and acoustic cues.

Diving

Sea turtle dive depth and duration varies by species, the age of the animal, the location of the animal, and the activity (i.e., foraging, resting, migrating). The diving behavior of a particular species or individual has implications for mitigation and monitoring. In addition, their relative distribution through the water column is an important consideration when conducting acoustic exposure analyses. The following text briefly describes the dive behavior of each species.

Green sea turtle. In the open ocean, Hatase et al. (2006) observed that green sea turtles dive to a maximum of 260 feet (79 m). Open-ocean resting dives rarely exceed 50 feet (15 m), while most open-ocean foraging dives average about 80 feet (24 m) (Hatase et al., 2006). A difference in duration between night and day dives was observed, with day dives lasting 1 to 18 minutes and night dives averaging 35 to 44 minutes (Rice and Balazs, 2008). In their coastal habitat, green sea turtles typically make dives shallower than 100 feet (31 m), with most dives not exceeding 58 feet (18 m) (Hays et al., 2004a; Rice and Balazs, 2008). Green sea turtles are known to forage and also rest at depths of 65 to 165 feet (20 to 50 m) (Balazs, 1980; Brill et al., 1995).

Hawksbill turtle. Hawksbill turtles make short, active foraging dives during the day, and longer resting dives at night (Blumenthal et al., 2009; Storch et al., 2005; Van Dam and Diez, 1996). Lutcavage and Lutz (1997) cited a maximum dive duration of 73.5 minutes for a female hawksbill in the U.S. Virgin Islands. Van Dam and Diez (1996) reported that foraging dives at a study site in the northern Caribbean ranged from 19 to 26 minutes at depths of 25 to 35 feet (8 to 11 m), with resting night dives ranging from 35 to 47 minutes (Van Dam and Diez, 1996). Foraging dives of immature hawksbills are shorter, ranging from 8.6 to 14 minutes in duration (Van Dam and Diez, 1996), with a mean and maximum depth of 5 feet (1.5 m) and 65 feet (20 m), respectively (Blumenthal et al., 2009; Van Dam and Diez, 1996).

Loggerhead turtle. Loggerhead turtles foraging in nearshore habitat dive to the seafloor (average depth 165 to 490 feet [50 to 149 m]) and those in open-ocean habitat dive in the 0 to 80 feet (0 to 24 m) depth range (Hatase et al., 2007). Dive duration was significantly longer at night, and increased in warmer waters. The average overall dive duration was 25 minutes, although dives exceeding 300 minutes were recorded. Turtles in open-ocean habitat exhibited mid-water resting dives at around 45 feet (14 m), where they could remain for many hours. This (resting) appears to be the main function of many of the night dives recorded (Hatase et al., 2007). Another study on coastal foraging loggerheads by Sakamoto et al. (1993) found that virtually all dives were shallower than 100 feet (31 m).

On average, loggerhead turtles spend over 90 percent of their time underwater (Byles, 1988; Renaud and Carpenter, 1994). Studies investigating dive characteristics of loggerheads under various conditions confirm that loggerheads do not dive particularly deep in the open-ocean environment (approximately 80 feet [24 m]) but will forage to bottom depths of at least 490 feet (149 m) in coastal habitats (Hatase et al., 2007; Polovina et al., 2002; Soma, 1985).

Olive ridley sea turtle. Most studies on olive ridley diving behavior have been conducted in shallow coastal waters (Beavers and Cassano, 1996; Sakamoto et al., 1993). However, Polovina et al. (2002) radio tracked two olive ridleys (and two loggerheads) caught in commercial fisheries. The results showed that the olive ridleys dove deeper than loggerheads, but spent only about 10 percent of time at depth under 100 feet (31 m). Daily dives of 200 m (656 feet) occurred, with one dive recorded at 254 m (833 feet) (Polovina et al., 2002). The deeper-dive distribution of olive ridleys is also consistent with their oceanic habitat, which differs from the loggerhead habitat.

Leatherback sea turtle. The leatherback is the deepest diving sea turtle, with a recorded maximum depth of 4,200 feet (1,280 m), although most dives are much shallower (usually less than 820 feet [250 m]) (Hays et al., 2004; Sale et al., 2006). Diving activity (including surface time) is influenced by a suite of environmental factors (e.g., water temperature, availability and vertical distribution of food resources, bathymetry) that result in spatial and temporal variations in dive behavior (James et al., 2006; Sale et al., 2006). Leatherbacks dive deeper and longer in the lower latitudes than in the higher latitudes (James et al., 2005a), where they are known to dive in waters with temperatures just above freezing (James et al., 2006; Jonsen et al., 2007). James et al. (2006) noted that dives in higher latitudes are punctuated by longer surface intervals, perhaps in part to thermoregulate (i.e., bask). Tagging data also revealed that changes in individual turtle diving activity appear to be related to water temperature, suggesting an influence of seasonal prey availability on diving behavior (Hays et al., 2004). In their warm-water nesting habitats, dives are likely constrained by bathymetry adjacent to nesting sites during this time (Myers and Hays, 2006). For example, patterns of relatively deep diving are recorded off St. Croix in the Caribbean (Eckert et al., 1986) and Grenada (Myers and Hays, 2006) in areas where deep waters are close to shore. A maximum depth of 1,560 feet (476 m) was recorded (Eckert et al., 1986), although even deeper dives were inferred where dives exceeded the maximum range of the time depth recorder (Eckert, Eckert, Poganis et al., 1989). Shallow diving occurs where shallow water is close to the nesting beach.

Information on the diving behavior of each species of sea turtle was compiled in a Navy Technical Report (U.S. Department of the Navy, 2011) that summarizes time-at-depth for the purpose of distributing animals within the water column for acoustic exposure modeling.

Vocalization and Hearing

The auditory system of sea turtles appears to work via water and bone conduction, with lower-frequency sound conducted through the skull and shell, and does not appear to function well for hearing in air (Lenhardt et al., 1983; Lenhardt et al., 1985). Sea turtles do not have external ears or ear canals to channel sound to the middle ear, nor do they have a specialized eardrum. Instead, fibrous and fatty tissue layers on the side of the head may be the sound-receiving membrane in the sea turtle, a function similar to that of the eardrum in mammals, or may serve to release energy received via bone conduction (Lenhardt et al., 1983). Sound is transmitted to the middle ear, where sound waves cause movement of cartilaginous and bony structures that interact with the inner ear (Ridgway, 1969). Unlike mammals, the cochlea of the sea turtle is not elongated and coiled, and likely does not respond well to high frequencies, a hypothesis supported by a limited amount of information on sea turtle auditory sensitivity (Ridgway, 1969; Bartol, 1999).

Investigations suggest that sea turtle auditory sensitivity is limited to low-frequency bandwidths, such as those produced by waves breaking on a beach. The role of underwater low-frequency hearing in sea turtles is unclear. Sea turtles may use acoustic signals from their environment as guideposts during migration and as cues to identify their natal beaches (Lenhardt et al., 1983). Sea turtles are low-frequency hearing specialists, typically hearing frequencies from 30 to 2,000 hertz (Hz), with a range of maximum sensitivity between 100 and 800 Hz (Bartol, 1999; Ridgway, 1969; Lenhardt, 1994; Bartol and Ketten, 2006; Lenhardt, 2002). Hearing below 80 Hz is less sensitive but still potentially usable (Lenhardt, 1994). Greatest sensitivities are from 300 to 400 Hz for the green sea turtle (Ridgway, 1969) and around 250 Hz or below for juvenile loggerheads (Bartol, 1999). Bartol et al. (1999) reported that the range of effective hearing for juvenile loggerhead sea turtles is from at least 250 to 750 Hz using the auditory brainstem response technique. Juvenile and sub-adult green sea turtles detect sounds from 100 to 500 Hz underwater, with maximum sensitivity at 200 and 400 Hz (Bartol and Ketten, 2006). Auditory brainstem response recordings on green sea turtles showed a peak response at 300 Hz (Yudhana et al., 2010). Juvenile Kemp's ridley turtles detected underwater sounds from 100 to 500 Hz, with a maximum sensitivity between 100 and 200 Hz (Bartol and Ketten, 2006). Audiometric information is not available for leatherback sea turtles; however, their anatomy suggests they would hear similarly to other sea turtles. Functional hearing is assumed for this analysis to be 10 Hz to 2 kHz.

Sub-adult green sea turtles show, on average, the lowest hearing threshold at 300 Hz (93 decibels referenced to 1 microPascal [dB re 1 μPa]), with thresholds increasing at frequencies above and below 300 Hz, when thresholds were determined by auditory brainstem response (Bartol and Ketten, 2006). Auditory brainstem response testing was also used to detect thresholds for juvenile green sea turtles (lowest threshold 93 dB re 1 μPa at 600 Hz) and juvenile Kemp's ridley sea turtles (thresholds above 110 dB re 1 μPa across hearing range) (Bartol and Ketten, 2006). Auditory thresholds for yearling and two-year-old loggerhead sea turtles were also recorded. Both yearling and two-year-old loggerhead sea turtles had the lowest hearing threshold at 500 Hz (yearling: approximately 81 dB re 1 μPa and two-year-olds: approximately 86 dB re 1 μPa), with thresholds increasing rapidly above and below that frequency (Ketten and Bartol, 2006). In terms of sound production, nesting leatherback turtles were recorded producing sounds (sighs or belch-like sounds) up to 1,200 Hz with most energy ranging from 300 to 500 Hz (Bartol and Ketten, 2006).

General Threats

The sea turtle species in the study area have unique life histories and habitats; however, threats are common among all species. On beaches, wild domestic dogs, pigs, and other animals ravage sea turtle nests. Humans continue to harvest eggs and nesting females in some parts of the world, threatening some Pacific Ocean sea turtle populations (Maison et al., 2010). Coastal development can cause beach erosion and introduce non-native vegetation, leading to a subsequent loss of nesting habitat. It can also introduce or increase the intensity of artificial light, confusing hatchlings and leading them away from the water, thereby increasing the chances of hatchling mortality. Threats in nearshore foraging habitats include fishing and habitat degradation. Fishing can injure or drown juvenile and adult sea turtles. Habitat degradation, such as poor water quality, invasive species, and disease, can alter ecosystems, limiting the availability of food and altering survival rates.

Bycatch in commercial fisheries, ship strikes, and marine debris are primary threats in the offshore environment (Lutcavage, 1997). One comprehensive study estimated that, worldwide, 447,000 sea turtles are killed each year from bycatch in commercial fisheries (Wallace, 2010). Precise data are lacking for sea turtle mortalities directly caused by ship strikes. However, live and dead turtles are often found with deep cuts and fractures indicative of collision with a boat hull or propeller (Lutcavage, 1997; Hazel, 2007). Marine debris can also be a problem for sea turtles through entanglement or ingestion. Floating plastic garbage can be mistakenly ingested by sea turtles. Leatherback sea turtles in particular may mistake floating plastic garbage as jellyfish, an important component of the leatherback diet (Mrosovsky et al., 2009). Other marine debris, including derelict fishing gear and cargo nets, can entangle and drown turtles of all life stages.

3.2.1 **Green Sea Turtle (*Chelonia mydas*)**

The green sea turtle is found in tropical and subtropical coastal and open ocean waters, between 30° N and 30° South (S). Major nesting beaches are found throughout the western and eastern Atlantic, Indian, and western Pacific Oceans, including more than 80 countries worldwide (Hirth, 1997).

Status and Management

The green sea turtle was listed under the ESA in July 1978 because of excessive commercial harvest, a lack of effective protection, evidence of declining numbers, and habitat degradation and loss (NMFS and USFWS, 2007a). Recently, NMFS and USFWS revised DPS designations and corresponding ESA status for the green sea turtle, identifying three DPSs as endangered and eight DPSs as threatened (50 CFR Parts 223 and 224, April 6, 2016). The Central North Pacific DPS, which includes the Hawaiian Archipelago, is listed as threatened. Critical habitat is not currently designated for the Central North Pacific DPS, but could potentially be proposed in future rulemaking. Recovery plans have been prepared for Pacific Ocean green sea turtles (western and central Pacific populations) (NMFS and USFWS, 1998b).

Habitat and Geographic Range

Green sea turtles nest on beaches within the Insular Pacific-Hawaiian Large Marine Ecosystem. The eggs incubate in the sand for approximately 48 to 70 days. Green sea turtle hatchlings are 2 inches (5 centimeters [cm]) long, and weigh approximately 1 ounce (oz.) (28 grams [g]). When they leave the nesting beach, hatchlings begin an oceanic phase (Carr, 1987), floating passively in current systems (gyres), where they develop (Carr and Meylan, 1980). Hatchlings live at the surface in the open ocean for approximately one to three years (Hirth, 1997). Upon reaching the juvenile stage (estimated at five to six years and shell length of 8 to 10 inches [20 to 25 cm]), they move to lagoons and coastal areas that are rich in seagrass and algae (Bresette et al., 2006; Musick and Limpus, 1997). The optimal habitats for late juveniles and adults are warm, quiet, shallow waters (depths of 10 to 33 feet) (3 to 10 m), with seagrasses and algae, that are near reefs or rocky areas used for resting (Makowski et al., 2006). This habitat is where they will spend most of their lives (Bjorndal and Bolten, 1988; Makowski et al., 2006; NMFS and USFWS, 1991). A small number of green sea turtles appear to remain in the open ocean for extended periods, perhaps never moving to coastal feeding sites (NMFS and USFWS, 2007a; Pelletier et al., 2003).

Green sea turtles are known to live in the open ocean during the first five to six years of life, but little is known about preferred habitat or general distribution during this life phase. Migratory routes within the open ocean are unknown. The main source of information on distribution comes from catches in U.S. fisheries. About 57 percent of green sea turtles (primarily adults) captured in longline fisheries in the North Pacific Subtropical Gyre and North Pacific Transition Zone come from the Mexican nesting population, while 43 percent are from the Hawaiian nesting populations. The Hawaii-based longline tuna fishery is active on the high seas, between 15 °N and 35° N and 150° West (W) to 180° W. The Hawaii-based longline swordfish fishery is active on the high seas northeast of the Hawaiian Islands in the North Pacific Transition Zone (Gilman et al., 2007). These findings suggest that green sea turtles found on the high seas of the western and central Pacific Ocean are from these two populations.

Green sea turtles are estimated to reach sexual maturity at 20 to 50 years of age. This prolonged time to maturity has been attributed to their low-energy plant diet (Bjorndal, 1995), and may be the highest age for maturity of all sea turtle species (Chaloupka and Musick, 1997; Hirth, 1997; NMFS and USFWS, 2007a).

Once mature, green sea turtles may reproduce for a span of 17 to 23 years, nesting every 2 to 5 years (Carr et al., 1978; Hirth, 1997). This irregular pattern can cause wide year-to-year changes in numbers of nesting females at a given nesting beach. Each female nests three to five times per season, laying an average of 115 eggs in each nest (clutch). A female green sea turtle may deposit 9 to 33 clutches in a lifetime. With an average of approximately 100 eggs per nest, a female green sea turtle may lay 900 to 3,300 eggs in a lifetime (NMFS and USFWS, 2007a).

When green sea turtles are not breeding, adults live in coastal feeding areas that they sometimes share with juveniles (Seminoff and Marine Turtle Specialist Group Green Turtle Task Force, 2004). Green sea turtles of all ages have a dedicated home range, in which they repeatedly visit the same feeding and breeding areas (Bresette et al., 1998; Makowski et al., 2006).

The green sea turtle is the most common sea turtle species in the Hawaii region, occurring in the coastal waters of the Main Hawaiian Islands throughout the year and commonly migrating seasonally to the Northwestern Hawaiian Islands to reproduce. In the spring of 2010, two green sea turtles nested at PMRF for the first time in more than a decade, with successful hatching in August 2010 (O'Malley, 2010).Green sea turtles are found in inshore waters around all of the Main Hawaiian Islands and Nihoa Island, where reefs, their preferred habitats for feeding and resting, are most abundant. They are also common in an oceanic zone surrounding the Hawaiian Islands. This area is frequently inhabited by adults migrating to the Northwestern Hawaiian Islands to reproduce during the summer and by ocean-dwelling individuals that have yet to settle into coastal feeding grounds of the Main Hawaiian Islands. Farther offshore, green sea turtles occur in much lower numbers and densities.

More than 90 percent of all Hawaiian Island green sea turtle breeding and nesting occurs at French Frigate Shoals in the Northwestern Hawaiian Islands, the largest nesting colony in the central Pacific Ocean, where 200 to 700 females nest each year (NMFS and USFWS, 2007a). A large foraging population resides in and returns to the shallow waters surrounding the Main Hawaiian Islands (especially around Maui and Kauai), where they are known to come ashore at several locations on all eight of the Main Hawaiian Islands for basking or nesting.

Population and Abundance

Based on data from 46 nesting sites around the world, between 108,761 and 150,521 female green sea turtles nest each year (NMFS and USFWS, 2007a), which is a 48 to 65 percent decline in the number of females nesting annually over the past 100 to 150 years (Seminoff and Marine Turtle Specialist Group Green Sea Turtle Task Force, 2004). Of nine major nesting populations in the Pacific Ocean, four appear to be increasing (Hawaii, Mexico, Japan, Heron Island), three appear to be stable (Galapagos, Guam, Mexico), and the trend is unknown for two (Central American Coast and Raine Island). In addition to these sites, at least 166 smaller nesting sites are scattered across the western Pacific Ocean, with an estimated 22,800 to 42,580 females nesting in the Pacific Ocean each year (Maison et al., 2010; NMFS and USFWS, 2007a). Outside of the United States, the harvest of eggs and females for their meat on nesting beaches across the Pacific Ocean remains a primary threat to the species (Maison et al., 2010).

In Hawaii, 200 to 700 females nest annually at French Frigate Shoals, as well as on the Island of Hawaii and other minor nesting grounds on other Main Hawaiian Islands (NMFS and USFWS, 2007b). Nesting has been documented in recent years (up to and including 2015) at beach areas of PMRF. The Hawaiian population is under review for being considered a distinct stock (Central North Pacific DPS). Individuals spend most of their lives within the Insular Pacific-Hawaiian Large Marine Ecosystem. This population appears to have increased gradually over the past 30 years, with near-capacity nesting at French Frigate Shoals (Balazs and Chaloupka, 2006; Chaloupka et al., 2008b).

Predator and Prey Interactions

The green sea turtle is the only sea turtle that is mostly herbivorous (Mortimer, 1995), although its diet changes throughout its life. While at the surface, hatchlings feed on floating patches of seaweed and, at shallow depths, on comb jellies and gelatinous eggs, appearing to ignore large jellyfish (Salmon et al., 2004). While in the open ocean, juveniles smaller than 8 to 10 inches (20 to 25 cm) eat worms, small crustaceans, aquatic insects, grasses, and algae (Bjorndal, 1997). After settling into a coastal habitat, juveniles eat mostly seagrass or algae (Balazs et al., 1994; Mortimer, 1995). Some juveniles and adults that remain in the open ocean, and even those in coastal waters, also consume jellyfish, sponges, and sea pens (Blumenthal et al., 2009; Godley et al., 1998; Hatase et al., 2006; Heithaus et al., 2002; NMFS and USFWS, 2007a; Parker and Balazs, 2005).

Predators of green sea turtles vary according to turtle location and size. Land predators that feed on eggs and hatchlings include ants, crabs, birds, and mammals such as dogs, raccoons, and feral pigs. Aquatic predators, mostly fish and sharks, impact hatchlings most heavily in nearshore areas. Sharks are also the primary predators of juvenile and adult turtles (Stancyk, 1982).

3.2.2 **Hawksbill Sea Turtle (*Eretmochelys imbricata*)**

The hawksbill turtle is the most tropical of the world’s sea turtles, rarely occurring higher than 30° N or 30° S in the Atlantic, Pacific, and Indian Oceans (Lazell, 1980). It inhabits coastal waters in more than 108 countries and nests in at least 70 countries (NMFS and USFWS, 2007b).

Status and Management

The hawksbill turtle is listed as endangered under the ESA. Critical habitat has not been designated for the hawksbill in the Pacific Ocean. While the current listing as a single global population remains valid at this time, data may support separating populations at least by ocean basin under the distinct population segment policy (NMFS and USFWS, 2007b), which would lead to specific management plans for each designated population. The hawksbill shell has been prized for centuries for jewelry and other adornments. This trade, prohibited under the Convention on International Trade in Endangered Species, remains a critical threat to the species.

Habitat and Geographic Range

Hawksbills are considered the most coastal of the sea turtles that inhabit the Study Area, with juveniles and adults preferring coral reef habitats (NMFS, 2010b). Reefs provide shelter for resting hawksbills day and night, and they are known to visit the same resting spot repeatedly. Hawksbills are also found around rocky outcrops and high-energy shoals—optimum sites for sponge growth—as well as in mangrove-lined bays and estuaries (NMFS, 2010b).

Hatchling and early juvenile hawksbills have also been found in the open ocean, in floating mats of seaweed (Maison et al., 2010; Musick and Limpus, 1997). Although information about foraging areas is largely unavailable due to research limitations, juvenile and adult hawksbills may also be present in open ocean environments (NMFS and USFWS, 2007b).

Hawksbills are mostly found in the coastal waters of the eight main islands of the Hawaiian Island chain. Stranded or injured hawksbills are occasionally found in the Northwestern Hawaiian Islands (Parker et al., 2009). Hawksbills are the second-most-common species in the offshore waters of the Hawaiian Islands, yet they are far less abundant than green sea turtles (Chaloupka et al., 2008b). The lack of hawksbill sightings during aerial and shipboard surveys likely reflects the species’ small size and difficulty in identifying them from a distance.

Hawksbills primarily nest on the southeastern beaches of the Island of Hawaii (Aki et al., 1994). Since 1991, 81 nesting female hawksbills have been tagged on the Island of Hawaii at various locations. This number does not include nesting females from Maui or Molokai, which would add a small number to the total. Post-nesting hawksbills have been tracked moving between Hawaii and Maui over the deep waters of the Alenuihaha Channel (Parker et al., 2009).

Hawksbills were once thought to be non-migratory because of the proximity of suitable nesting beaches to coral reef feeding habitats and the high rates of marked turtles recaptured in these areas; however, tagging studies have shown otherwise. For example, a post-nesting female traveled 995 miles (1,601 km) from the Solomon Islands to Papua New Guinea (Meylan, 1995), indicating that adult hawksbills can migrate distances comparable to those of green and loggerhead sea turtles. However, research suggests that movements of Hawaiian hawksbills are relatively short, with individuals generally migrating through shallow coastal waters and few deepwater transits between the islands. Nine hawksbill turtles were tracked within the Hawaiian Islands using satellite telemetry. Turtles traveled from 55 to 215 miles (89 to 346 km) and took between 5 and 18 days to complete the trip from nesting to foraging areas (Parker et al., 2009).

Foraging dive durations are often a function of turtle size, with larger turtles diving deeper and longer. Shorter and more active foraging dives occur predominantly during the day, while longer resting dives occur at night (Blumenthal et al., 2009; Storch et al., 2005; Van Dam and Diez, 1997). Lutcavage and Lutz (1997) cited a maximum dive duration of 73.5 minutes for a female hawksbill in the U.S. Virgin Islands. Van Dam and Diez (2000) reported that foraging dives at a study site in the northern Caribbean ranged from 19 to 26 minutes at depths of 26 to 33 feet (8 to 10 m), with resting night dives from 35 to 47 minutes. Foraging dives of immature hawksbills are shorter, ranging from 8.6 to 14 minutes, with a mean and maximum depth of 16.4 and 65.6 feet (5 and 20 m), respectively (Van Dam and Diez, 1996). Blumenthal et al. (2009) reported consistent diving characteristics for juvenile hawksbill in the Cayman Islands, with an average daytime dive depth of 25 feet (8 m), a maximum depth of 140 feet (43 m), and a mean nighttime dive depth of 15 feet (5 m). A change in water temperature affects dive duration; cooler water temperatures in the winter result in increased nighttime dive durations (Storch et al., 2005).

Population and Abundance

A lack of nesting beach surveys for hawksbill turtles in the Pacific Ocean and the poorly understood nature of this species' nesting have made it difficult for scientists to assess the population status of hawksbills in the Pacific (NMFS and USFWS, 1998c; Seminoff, Nichols et al., 2003). An assessment of 25 sites around the world indicates that hawksbill nesting has declined by at least 80 percent over the last three generations (105 years in the Atlantic and 135 years in the Indo-Pacific Ocean) (Meylan and Donnelly, 1999). Only five regional populations remain worldwide (two in Australia, and one each in Indonesia, the Seychelles, and Mexico), with more than 1,000 females nesting annually (Meylan and Donnelly, 1999). The largest of these regional populations is in the South Pacific Ocean, where 6,000 to 8,000 hawksbills nest off the Great Barrier Reef (Limpus, 1992).

As with all other turtle species, hawksbill hatchlings enter an oceanic phase, and may be carried great distances by surface currents. Although little is known about their open ocean stage, younger juvenile hawksbills have been found in association with brown algae in the Pacific Ocean (Musick and Limpus, 1997; Parker, 1995; Witherington and Hirama, 2006; Witzell, 1983) before settling into nearshore habitats as older juveniles. Preferred habitat is coral reefs, but hawksbills also inhabit seagrass, algal beds, mangrove bays, creeks, and mud flats (Mortimer and Donnelly, 2008). Some juveniles may use the same feeding grounds for a decade or more (Meylan, 1999), while others appear to migrate among several sites as they age (Musick and Limpus, 1997). Indo-Pacific hawksbills are estimated to mature at between 30 and 38 years of age (Mortimer and Donnelly, 2008).

Once they are sexually mature, hawksbill turtles undertake breeding migrations between foraging grounds and breeding areas at intervals of several years (Dobbs et al., 1999; Mortimer and Bresson, 1999; Witzell, 1983). Although females tend to return to breed where they were born (Bowen and Karl, 1997), they may have foraged hundreds or thousands of kilometers from their birth beaches as juveniles.

Hawksbills are solitary nesters. Females nest every two to three years at night. A female hawksbill lays between three and five clutches during a single nesting season, which contain an average of 130 eggs per clutch (Mortimer and Bresson, 1999; Richardson et al., 1999). In Hawaii, the nesting seasons runs approximately from May through December (Aki et al., 1994).

The Hawksbill Sea Turtle (*Eretmochelys imbricata*) 5-year Review: Summary and Evaluation (NMFS and USFWS, 2007b) assessed nesting abundance and trends in all regions that the species inhabits. Where possible, historical population trends were determined, and most showed declines for the 20 to 100 year period of evaluation. Recent trends for 42 of the sites indicated that 69 percent were decreasing, 7 percent were stable, and that 24 percent were increasing. The Hawaii site has a recent increasing trend.

Predator and Prey Interactions

Hawksbills eat both animals and algae during the early juvenile stage, feeding on prey such as sponges, algae, molluscs, crustaceans, and jellyfish (Bjorndal, 1997). Older juveniles and adults are more specialized, feeding primarily on sponges, which comprise as much as 95 percent of their diet in some locations, although the diet of adult hawksbills in the Indo-Pacific region includes other invertebrates and algae (Meylan, 1988; Witzell, 1983). The shape of their mouth allows hawksbills to reach into holes and crevices of coral reefs to find sponges and other invertebrates.

Predators of hawksbills vary according to turtle location and size. Land predators on eggs and hatchlings include ants, crabs, birds, and mammals such as dogs, raccoons, and feral pigs. Aquatic predators, mostly fish and sharks, impact hatchlings most heavily in nearshore areas. Sharks are also the primary predators of juvenile and adult turtles (Stancyk, 1982).

3.2.3 Loggerhead Sea Turtle (*Caretta caretta*)

Loggerhead sea turtles are one of the larger species of turtle, named for their large blocky heads that support powerful jaws used to feed on hard-shelled prey. The loggerhead is found in temperate to tropical regions of the Atlantic, Pacific, and Indian Oceans and in the Mediterranean Sea.

Status and Management

The loggerhead was the subject of a complete stock analysis conducted to identify distinct population segments within the global population (Conant et al., 2009). Three distinct population segments occur in the Pacific Ocean: North Pacific, South Pacific, and Southeast Indo-Pacific Ocean. The Hawaii region occurs within the range of the North Pacific population. Genetic data (Bowen et al., 1995; Resendiz et al., 1998) and tagging data (Conant et al., 2009) indicate that the South Pacific and Southeast Indo-Pacific Ocean nesting populations rarely, if ever, are found in northern Pacific Ocean waters. North Pacific Ocean loggerheads nest exclusively in Japan. Based on a review of census data collected from most of the Japanese beaches from the 1950s through the 1990s, Kamezaki et al. (2003) concluded that the annual loggerhead nesting population in Japan declined 50 to 90 percent in recent decades. Loggerheads are declining and at risk of extirpation from the northern Pacific Ocean. This drop in numbers is primarily the result of fishery bycatch from the coastal pound net fisheries off Japan, coastal fisheries that affect juvenile foraging populations off Baja California, and undescribed fisheries that likely affect loggerheads in the South China Sea and the northern Pacific Ocean (NMFS and USFWS, 2007d). The North Pacific Ocean DPS is listed under the ESA as endangered because of the significance of threats to the species, small current nesting population, and estimated historical decline in the nesting population. Critical Habitat is currently not designated for Pacific Ocean loggerheads.

Habitat and Geographic Range

The loggerhead turtle is found in habitats ranging from coastal estuaries to the open ocean (Dodd, 1988). Most of the loggerheads observed in the eastern North Pacific Ocean are believed to come from beaches in Japan where the nesting season is late May to August (NMFS and USFWS, 1998e). Migratory routes can be coastal or can involve crossing deep ocean waters (Schroeder et al., 2003). The species can be found hundreds of kilometers out to sea, as well as in inshore areas, such as bays, lagoons, salt marshes, creeks, ship channels, and the mouths of large rivers. Coral reefs, rocky places, and shipwrecks are often used as feeding areas. The nearshore zone provides crucial foraging habitat, as well as internesting and overwintering habitat.

Loggerheads typically nest on beaches close to reef formations and adjacent to warm currents (Dodd, 1988). They prefer nesting beaches facing the open ocean or along narrow bays (Conant et al., 2009). Nesting beaches tend to be wide and sandy, backed by low dunes and fronted by a flat sandy approach from the water (Miller et al., 2003). Nests are typically laid between the high tide line and the dune front (Hailman and Elowson, 1992).

Pacific Ocean loggerheads appear to use the entire North Pacific Ocean during development. There is substantial evidence that the North Pacific Ocean stock makes two transoceanic crossings. The first crossing (west to east) is made immediately after they hatch from the nesting beach in Japan, while the second (east to west) is made when they reach either the late juvenile or adult life stage at the foraging grounds in Mexico. Offshore, juvenile loggerheads forage in or migrate through the North Pacific Subtropical Gyre as they move between North American developmental habitats and nesting beaches in Japan. The highest densities of loggerheads can be found just north of Hawaii in the North Pacific Transition Zone (Polovina et al., 2000).

The North Pacific Transition Zone is defined by convergence zones of high productivity that stretch across the entire northern Pacific Ocean from Japan to California (Polovina et al., 2001). Within this gyre, the Kuroshio Extension Bifurcation Region is an important habitat for juvenile loggerheads (Polovina et al., 2006). These turtles, whose oceanic phase lasts a decade or more, have been tracked swimming against the prevailing current, apparently to remain in the areas of highest productivity. Juvenile loggerheads originating from nesting beaches in Japan migrate through the North Pacific Transition Zone en route to important foraging habitats in Baja California (Bowen et al., 1995).

NMFS and USFWS (1998e) listed four sighting records of this species for the Hawaiian Islands, all juveniles. A single male loggerhead turtle has also been reported to visit Lehua Channel and Keamano Bay (located off the northern coast of Niihau) every June through July (U.S. Department of the Navy, 2001a; U.S. Department of the Navy, 2002). Only one loggerhead stranding has been recorded in the Hawaiian Islands since 1982 (NMFS, 2004). While incidental catches of loggerheads in the Hawaii-based longline fishery indicate that they use these waters during migrations and development (Polovina et al., 2000), their occurrence in the offshore waters of Hawaii is believed to be rare.

Diving profiles in open ocean and nearshore habitats appear to be based on the location of the food source, with turtles foraging in the nearshore habitat diving to the seafloor (average depth 165 to 330 feet) (50 to 101 m) and those in the open ocean habitat diving exclusively in the 0 to 80 feet (0 to 24 m) depth range (Hatase et al., 2007). Dive duration increased in warmer waters. The average foraging dive duration was 25 minutes, although night resting dives to depths of 45 feet (14 m) longer than 300 minutes were recorded. Resting appears to be the main function of night dives (Hatase et al., 2007).

A diving study of two longline-caught loggerheads in the Central North Pacific Ocean showed that the turtles spent about 40 percent of their time in the top 3 feet (0.9 m), 70 percent of the dives were no deeper than 15 feet (4.6 m), and virtually all of their time was spent in water shallower than 330 feet (101 m) (Polovina et al., 2002).

Population and Abundance

The global population of loggerhead turtles is estimated at 43,320 to 44,560 nesting females (NMFS and USFWS, 2007d). The largest nesting populations occur in the subtropics on the western rims of the Atlantic and Indian Oceans. The largest nesting aggregation in the Pacific Ocean occurs in southern Japan, where fewer than 1,000 females breed annually (Kamezaki et al., 2003). Seminoff et al. (2004)

carried out aerial surveys for loggerhead turtles along the Pacific Coast of the Baja California Peninsula, Mexico an area long thought to be critical habitat for juveniles. Surveys were carried out from September to October 2005 and encompassed nearly 7,000 km of track-line with offshore extents to 170 km. More than 400 turtles were sighted. Loggerheads were the most prevalent (77 percent of all sightings). Olive ridleys (12 percent), green turtles (7 percent), and leatherback turtles (less than 1 percent) were also sighted.

Females lay three to five clutches of eggs, and sometimes lay additional clutches, during a single nesting season (NMFS and USFWS, 2007d). Mean clutch size is approximately 100 to 130 eggs (Dodd, 1988). The temperature of a viable nest ranges between 79°F and 90°F (26°C and 32°C). Eggs incubate for approximately two months before they hatch (Mrosovsky, 1980). As with all sea turtles, an incubation temperature near the upper end of the viable range (90°F [32°C]) produces all females, and an incubation temperature near the lower end (79°F [26°C]) produces all male hatchlings (Mrosovsky, 1980).

Hatchlings travel to oceanic habitats, and often are found in seaweed drift lines (Carr, 1986, 1987; Witherington and Hirama, 2006). Loggerheads spend the first 7 to 11.5 years of their lives in the open ocean (Bolten, 2003). At about 14 years old, some juveniles move to nearshore habitats close to their birth area, while others remain in the oceanic habitat or move back and forth between the two (Musick and Limpus, 1997). Turtles may use the same nearshore developmental habitat all through maturation or may move among different areas, finally settling in an adult foraging habitat. Loggerheads reach sexual maturity at around 35 years of age, and move from subadult to adult coastal foraging habitats (Godley et al., 2003; Musick and Limpus, 1997). Data from Japan (Hatase et al., 2002), Cape Verde (Hawkes et al., 2006), and Florida (Reich et al., 2007) indicate that at least some of the adult population forages in the open ocean.

Predator and Prey Interactions

In both open ocean and nearshore habitats, loggerheads are primarily carnivorous, although they also consume some algae (Bjorndal, 1997; Dodd, 1988). Both juveniles and adults forage in coastal habitats, where they feed primarily on the bottom, although they also capture prey throughout the water column (Bjorndal, 2003). Adult loggerheads feed on a variety of bottom-dwelling animals, such as crabs, shrimp, sea urchins, sponges, and fish. They have powerful jaws that enable them to feed on hard-shelled prey, such as whelks and conch. During migration through the open sea, they eat jellyfish, molluscs, flying fish, and squid.

Polovina et al. (2006) found that juvenile loggerheads in the western North Pacific Ocean at times swim against weak prevailing currents because they are attracted to areas of high productivity. Similar observations have been made in the Atlantic (Hawkes et al., 2006). These results suggest that the location of currents and associated frontal eddies is important to the loggerhead's foraging during its open ocean stage (McClellan and Read, 2007).

3.2.4 Olive Ridley Sea Turtle (*Lepidochelys olivacea*)

The olive ridley is a relatively small, hard-shelled sea turtle named for its olive green top shell. The olive ridley is known as an open ocean species, but can also be found in coastal areas. They are found in tropical waters of the south Atlantic, Indian, and Pacific Oceans. While the olive ridley is the most abundant sea turtle species in the world (NMFS and USFWS, 1998f), with some of the largest nesting beaches occurring along the Pacific coast of Central America, few data about its occurrence in the study area are available.

Status and Management

The Mexican Pacific Ocean coast nesting population has been classified as endangered because of extensive overharvesting of olive ridley turtles in Mexico, which caused a severe population decline. All other populations are listed under the ESA as threatened. Before this commercial exploitation, the olive ridley was highly abundant in the eastern tropical Pacific Ocean, probably outnumbering all other sea turtle species combined (NMFS and USFWS, 1998f). Today, this population appears to be stable or increasing (NMFS and USFWS, 2007e), although the decline of the species continues at several important nesting beaches in Central America. Critical habitat has not been designated for the olive ridley.

Available information indicates that the population could be separated by ocean basins under the distinct population segment policy (NMFS and USFWS, 2007e). Based on genetic data, the worldwide olive ridley population is composed of four main lineages: east India, Indo-Western Pacific, Atlantic, and eastern Pacific Ocean (Bowen et al., 1998; Shankar et al., 2004).

Habitat and Geographic Range

Most olive ridley turtles lead a primarily open ocean existence (NMFS and USFWS, 1998f). The turtles disperse outside of the breeding season, but little is known of their foraging habitats or migratory behavior. Neither males nor females migrate to one specific foraging area, but tend to roam and occupy a series of feeding areas in the open ocean (Plotkin et al., 1994). The olive ridley has a large range in tropical and subtropical regions in the Pacific Ocean, and is generally found between 40° N and 40° S. Both adult and juvenile olive ridley turtles typically inhabit offshore waters, foraging from the surface to a depth of 490 feet (149.4 m) (NMFS and USFWS, 1998f).

The second-most-important nesting area for olive ridley turtles, globally, occurs in the eastern Pacific Ocean, along the western coast of southern Mexico and northern Costa Rica, with stragglers nesting as far north as southern Baja California (Fritts et al., 1982) and as far south as Peru (Brown and Brown, 1995). Individuals occasionally occur in waters as far north as California and as far south as Peru, spending most of their life in the oceanic zone (NMFS and USFWS, 2007e).

Data collected during tuna fishing cruises from Baja California to Ecuador, and from the Pacific coast to almost 150° W, indicated that the two most important areas in the Pacific Ocean for the olive ridley turtles are the Central American coast and the nursery and feeding area off Colombia and Ecuador. In these areas, both adults (mostly females) and juveniles are often seen (NMFS and USFWS, 1998f).

In the open ocean of the eastern Pacific Ocean, olive ridley turtles are often seen near floating debris, possibly feeding on associated fish and invertebrates (Pitman, 1992). Although no estimates are available, the highest densities of olive ridley turtles are likely found just south of Hawaii, as their distribution in the central Pacific Ocean is primarily tropical (Polovina et al., 2004). About 18 percent of the sea turtles incidentally caught by the Hawaii-based longline fishery, which operates throughout this region, are olive ridley turtles (NMFS and USFWS, 1998f; NMFS, 2011). Arenas and Hall (1992) found that 75 percent of sea turtles associated with floating objects in the eastern tropical Pacific Ocean were olive ridley turtles, which were present in 15 percent of the observations; this finding suggests that flotsam may provide the turtles with food, shelter, and orientation cues.

An estimated 31 olive ridley turtle strandings were recorded in the Hawaiian Islands between 1982 and 2003 (Chaloupka et al., 2008b). Few sightings have been recorded in the nearshore waters of the Main Hawaiian Islands and Nihoa. Available information suggests that olive ridley turtles traverse through the oceanic waters surrounding the Hawaiian Islands during foraging and developmental migrations. Genetic analysis of olive ridley turtles captured in the Hawaii-based longline fishery showed that 67 percent originated from the eastern Pacific Ocean (Mexico and Costa Rica), and 33 percent of the turtles were from the Indian and western Pacific Ocean rookeries (Polovina et al., 2004). These turtles were captured in deep, offshore waters of the Hawaiian Islands, primarily during spring and summer. Based on the oceanic habitat preferences of this species throughout the Pacific Ocean, this species is likely more prevalent year round in waters off the Hawaiian Islands beyond the 330 feet (100 m) isobath, with only rare occurrences inside this isobath.

The Pacific Ocean population migrates throughout the Pacific Ocean, from their nesting grounds in Mexico and Central America to the North Pacific Ocean (NMFS and USFWS, 2007e). The post-nesting migration routes of olive ridley turtles tracked via satellite from Costa Rica traversed thousands of kilometers of deep oceanic waters from Mexico to Peru, and more than 1,865 miles (3,000 km) out into the central Pacific Ocean (Plotkin et al., 1994). Tagged turtles nesting in Costa Rica were recovered as far south as Peru, as far north as Oaxaca, Mexico, and offshore to a distance of 1,080 NM (NMFS and USFWS, 1998f).

Groups of 100 or more turtles have been observed as far offshore as 120° W, at about 1,620 NM from shore (Arenas and Hall, 1992). Sightings of large groups of olive ridley turtles at sea reported by Oliver in 1946 (NMFS and USFWS, 1998f) may indicate that turtles travel in large flotillas between nesting beaches and feeding areas (Márquez M., 1990). Specific post-breeding migratory pathways to feeding areas do not appear to exist, although olive ridley turtles swim hundreds to thousands of kilometers over vast oceanic areas.

Olive ridley turtles can dive and feed at considerable depths (260 to 1,000 feet) (79 to 305 m) (NMFS and USFWS, 1998f), although only about 10 percent of their time is spent at depths greater than 330 feet (100 m) (Eckert et al., 1986; Polovina et al., 2002). In the eastern tropical Pacific Ocean, at least 25 percent of their total dive time is spent between 65 and 330 feet (20 and 101 m) (Parker et al., 2003). In the North Pacific Ocean, two olive ridley turtles tagged with satellite-linked depth recorders spent about 20 percent of their time in the top meter and about 10 percent of their time deeper than 330 feet (100 m); a daily maximum depth exceeded 490 feet (149 m) at least once in 20 percent of the days, with one dive recorded at 835 feet (255 m). While olive ridley turtles are known to forage to great depths, 70 percent of the dives from this study were no deeper than 15 feet (4.6 m) (Polovina et al., 2002).

Population and Abundance

The olive ridley is the most abundant sea turtle in the world (Pritchard, 1997) and the most abundant sea turtle in the open ocean waters of the eastern tropical Pacific Ocean (Pitman, 1990). They nest in nearly 60 countries worldwide, with an estimated 800,000 females nesting annually (NMFS, 2010b). This is a dramatic decrease over the past 50 years, where the population from the five Mexican Pacific Ocean beaches was previously estimated at 10 million adults (Cliffton et al., 1995). The number of olive ridley turtles occurring in U.S. territorial waters is believed to be small (NMFS and USFWS, 1998f). At-sea abundance surveys conducted along the Mexican and Central American coasts between 1992 and 2006 provided an estimate of 1.39 million turtles in the region, which was consistent with the increases seen on the eastern Pacific Ocean nesting beaches between 1997 and 2006 (NMFS and USFWS, 2007e).

Little is known about the age and sex distribution, growth, birth and death rates, or immigration and emigration of olive ridley turtles. Hatchling survivorship is unknown, although presumably, as with other turtles, many die during the early life stages. Both adults and juveniles occur in open sea habitats, though sightings are relatively rare. The median age to sexual maturity is 13 years, with a range of 10 to 18 years (Zug et al., 2006).

Olive ridley turtles use two types of nesting strategies. In 18 locations around the world, they conduct annual synchronized nesting, a phenomenon known as an “arribada” (NMFS and USFWS, 1998f), where hundreds to tens of thousands of olive ridley turtles emerge over a period of a few days. In the eastern Pacific Ocean, arribada nesting occurs throughout the year, although it peaks from September to December (Fretey, 2001). Arribadas occur on several beaches in Mexico, Nicaragua, Costa Rica, and Panama. Olive ridley turtles also lay solitary nests throughout the world, although little attention has been given to this nesting strategy because of the dominant interest in arribada research (NMFS and USFWS, 2007e). Solitary nesting occurs in at least 46 countries throughout the world (Kalb and Owens, 1994), including along nearly the entire Pacific Ocean coast of Mexico, with the greatest concentrations closer to arribada beaches. In Hawaii, olive ridleys have been known to nest sporadically on the Island of Maui, at U.S. Marine Corps Base Hawaii on Oahu in 2009, and on the Ka’u coast on the Island of Hawaii in 2010.

Females and males begin to group in "reproductive patches" near their nesting beaches two months before the nesting season, and most mate near the nesting beaches, although mating has been observed throughout the year as far as 565 miles (909 km) from the nearest mainland (Pitman, 1990). Arribadas usually last from three to seven nights, and due to the sheer number of nesters, later arrivers disturb and dig up many existing nests, lowering overall survivorship during this phase (NMFS and USFWS, 1998f). A typical female produces two clutches per nesting season, averaging 105 eggs at 15 to 17 day intervals for lone nesters and 28 day intervals for mass nesters (NMFS and USFWS, 1998f; Plotkin et al., 1994). Studies show that females that nested in arribadas remain within 3 miles (4.8 km) of the beach most of the time during the internesting period (Kalb and Owens, 1994). Incubation time from egg deposition to hatching is approximately 55 days (Pritchard and Plotkin, 1995). Hatchlings emerge weighing less than 1 ounce (less than 28 g) and measuring about 1.5 inches (3.8 cm).

Predator and Prey Interactions

Olive ridley sea turtles are primarily carnivorous. They consume a variety of prey in the water column and on the seafloor, including snails, clams, tunicates, fish, fish eggs, crabs, oysters, sea urchins, shrimp, and jellyfish (Fritts, 1981; Márquez M., 1990; Mortimer, 1995; Polovina et al., 2004). Olive ridleys are subject to predation by the same predators as other sea turtles, such as sharks on adult olive ridleys, fish and sharks on hatchlings, and various land predators on hatchlings (e.g., ants, crabs, birds, and mammals) (NMFS and USFWS, 1998f).

3.2.5 Leatherback Sea Turtle (*Dermochelys coriacea*)

Leatherback turtles have several unique characteristics. They are distinguished from other sea turtles by their leathery shell, and they are the largest species of sea turtle; adults can reach 6.5 feet (2 m) in length (NMFS and USFWS, 1992). Leatherbacks are also the most migratory sea turtles, and are able to tolerate colder water than other species (Hughes et al., 1998; James and Mrosovsky, 2004). Leatherbacks are the deepest-diving sea turtle (Hays et al., 2004). They are found in tropical to temperate regions of the Atlantic, Indian, and Pacific Oceans. Leatherbacks are known as an open ocean species, but can also rarely be found in coastal waters within the Study Area.

Status and Management

In the Pacific Ocean, NMFS has identified two subpopulations: Western and Eastern Pacific leatherbacks. All leatherbacks are classified as endangered under the ESA. Western Pacific leatherbacks nest in the Indo-Pacific and migrate back to feeding areas off the Pacific coast of North America. Eastern Pacific leatherbacks nest along the Pacific coast of the Americas in Mexico and Costa Rica. Most stocks in the Pacific Ocean are faring poorly; Western Pacific leatherbacks have declined by more than 80 percent, while Eastern Pacific leatherbacks have declined by over 97 percent. In contrast, western Atlantic and South African populations are generally stable or increasing (Turtle Expert Working Group, 2007).

A total of 203 nesting beaches from 46 countries around the world have been identified (Dutton, 2006). The leatherback sea turtle has been reported to nest on the Island of Lanai in the past. Although these data are beginning to form a global perspective, unidentified sites likely exist, and incomplete or no data are available for many other sites. The Eastern Pacific subpopulation nests between Mexico and Ecuador, and the Western Pacific subpopulation nests in numerous countries, including Australia, Fiji, Indonesia, and China. Leatherbacks have been in decline in all major Pacific basin rookeries (nesting areas/groups) (NMFS and USFWS, 2007c; Turtle Expert Working Group, 2007) for at least the last two decades (Gilman, 2008; Sarti-Martinez et al., 1996; Spotila et al., 1996; Spotila et al., 2000). Causes for this decline include the nearly complete harvest of eggs and high levels of mortality during the 1980s, primarily in the high seas driftnet fishery, which is now banned (Chaloupka et al., 2004; Eckert and Sarti-Martinez, 1997; Gilman, 2008; Sarti-Martinez et al., 1996). With only four major rookeries remaining in the western Pacific Ocean and two in the eastern Pacific Ocean, the Pacific leatherback is at an extremely high risk of extinction (Gilman, 2008).

Habitat and Geographic Range

The leatherback turtle is the most widely distributed of all sea turtles, found from tropical to subpolar oceans, and nests on tropical and occasionally subtropical beaches (Gilman, 2008; Myers and Hays, 2006; NMFS and USFWS, 1992). Found from 71° N to 47° S, it has the most extensive range of any adult turtle (Eckert, 1995). Adult leatherback turtles forage in temperate and subpolar regions in all oceans, and migrate to tropical nesting beaches between 30° N and 20° S. Leatherbacks have a wide nesting distribution, primarily on isolated mainland beaches in tropical and temperate oceans (NMFS and USFWS, 1992), and to a lesser degree on some islands.

Hatchling leatherbacks head out to the open ocean, but little is known about their distribution for the first four years (Musick and Limpus, 1997). Sightings of turtles smaller than 55 inches (140 cm) indicate that some juveniles remain in coastal waters in some areas (Eckert et al., 1999).

Few quantitative data are available concerning the seasonality, abundance, or distribution of leatherbacks in the central northern Pacific Ocean. Satellite tracking studies and occasional incidental captures of the species in the Hawaii-based longline fishery indicate that deep ocean waters are the preferred habitats of leatherback turtles in the central Pacific Ocean (NMFS and USFWS, 2007c). The primary migration corridors for leatherbacks are across the North Pacific Subtropical Gyre, with the eastward migration route possibly to the north of the westward migration (Dutton, unpublished data).

The primary data available for leatherbacks in the North Pacific Transition Zone come from longline fishing bycatch reports, as well as several satellite telemetry data sets (Benson et al., 2007). Leatherbacks from both eastern and western Pacific Ocean nesting populations migrate to northern Pacific Ocean foraging grounds, where longline fisheries operate (Dutton et al., 1998). Leatherbacks from nesting beaches in the Indo-Pacific region have been tracked migrating thousands of kilometers through the North Pacific Transition Zone to summer foraging grounds off the coast of northern California (Benson et al., 2007). Based on the genetic sampling of 18 leatherback turtles caught in the Hawaiian longline fishery, about 94 percent originated from western Pacific Ocean nesting beaches (NMFS and USFWS, 2007c). The remaining 6 percent of the leatherback turtles found in the open ocean waters north and south of the Hawaiian Islands represent nesting groups from the eastern tropical Pacific Ocean.

Leatherback turtles are regularly sighted by fishermen in offshore waters surrounding the Hawaiian Islands, generally beyond the 3,800 feet (1,158 m) contour, and especially at the southeastern end of the island chain and off the northern coast of Oahu (Balazs, 1995). Leatherbacks encountered in these waters, including those caught accidentally in fishing operations, may be migrating through the Insular Pacific-Hawaiian Large Marine Ecosystem (NMFS and USFWS, 1998d). Sightings and reported interactions with the Hawaii longline fishery commonly occur around seamount habitats above the Northwestern Hawaiian Islands (from 35° N to 45° N and 175° W to 180° W) (Skillman and Balazs, 1992; Skillman and Kleiber, 1998).

The leatherback turtle occurs within the entire Insular Pacific-Hawaiian Large Marine Ecosystem beyond the 330 feet (100 m) isobath; occurrence is rare inside this isobath. Incidental captures of leatherbacks have also occurred at several offshore locations around the Main Hawaiian Islands (McCracken, 2000). Although leatherback bycatches are common off the island chain, leatherback-stranding events on Hawaiian beaches are uncommon. Since 1982, only five leatherbacks have stranded in the Hawaiian Islands (Chaloupka et al., 2008b). Leatherbacks were not sighted during aerial surveys which took place over waters lying close to the Hawaiian shoreline. Leatherbacks were also not sighted during NMFS shipboard surveys; their deep diving capabilities and long submergence times reduce the probability that observers could spot them during marine surveys. One leatherback turtle was observed along the Hawaiian shoreline during monitoring surveys in 2006 (Rivers, 2011).

The leatherback is the most oceanic and wide-ranging of sea turtles, undertaking extensive migrations along distinct depth contours for hundreds to thousands of kilometers (Hughes et al., 1998; Morreale et al., 1996). After they nest, female leatherbacks migrate from tropical waters to more temperate latitudes that support high densities of jellyfish in the summer. Late juvenile and adult leatherback turtles are known to range from mid-ocean to the continental shelf and nearshore waters (Frazier, 2001), foraging in coastal areas in temperate waters and offshore areas in tropical waters (Frazier, 2001). Their movements appear to be linked to the seasonal availability of their prey and the requirements of their reproductive cycle (Davenport and Balazs, 1991). Trans-Pacific Ocean migrations have been reported, including a 6,385 mile (10,276 km) migration from a nesting beach in Papua New Guinea to foraging grounds off the coast of Oregon (Benson et al., 2007).

Eighty percent of the leatherback's time at sea is spent diving (Fossette et al., 2007). The leatherback is the deepest diving sea turtle, with recorded depths of at least 4,035 feet (1,230 m) (Hays, Metcalfe et al., 2004), although most dives are much shallower, usually less than 655 feet (200 m) (Hays, Houghton et al., 2004; Sale et al., 2006). Leatherbacks spend most of their time in the upper 215 feet (66 m) of the water column (Jonsen et al., 2007). Diving is influenced by many factors, including water temperature and local availability and vertical distribution of food resources, resulting in variations in dive times and distances (James et al., 2006; Sale et al., 2006).

The dive time limit for the leatherback is estimated at between 33 and 67 minutes (Hays, Houghton et al., 2004; Hays, Metcalfe et al., 2004; Southwood et al., 1999), with typical durations of 6.9 to 14.5 minutes (Eckert et al., 1996). During migrations or long-distance movements, leatherbacks travel within 15 feet (4.8 m) of the surface (Eckert, 2002), making scouting dives to sample prey density and to feed on whatever is available (James et al., 2006; Jonsen et al., 2007).

In warm waters, leatherbacks dive deeper and longer (James et al., 2005), spending only short periods at the surface between dives (Eckert et al., 1986). While diving in colder waters, sometimes just above freezing, leatherbacks make shorter dives and spend up to 50 percent of their time at or near the surface (James et al., 2006; Jonsen et al., 2007).

Population and Abundance

The major nesting populations of the Eastern Pacific leatherbacks occur in Mexico, Costa Rica, Panama, Colombia, Ecuador, and Nicaragua (Chaloupka et al., 2004; Dutton et al., 1999; Eckert and Sarti-Martinez, 1997; Márquez M., 1990; Sarti-Martinez et al., 1996; Spotila et al., 1996), with the largest ones in Mexico and Costa Rica. There are 28 known nesting sites for the Western Pacific population, with an estimated 5,000 to 9,100 leatherback nests annually across the western tropical Pacific Ocean, from Australia and Melanesia (Papua New Guinea, Solomon Islands, Fiji, and Vanuatu) to Indonesia, Thailand, and China (Chaloupka et al., 2004; Chua, 1988; Dutton, 2006; Hirth et al., 1993; Suarez et al., 2000).

Leatherback hatchlings are approximately 2 to 3 inches (5 to 7.6 cm) long and weigh approximately 1.4 to 1.8 ounces (40 to 51 g). As with other sea turtle species, limited information is available on the open ocean habitats used by hatchling and early juvenile leatherbacks (NMFS and USFWS, 1992). Leatherbacks whose shell length is less than 40 inches (102 cm) have only been sighted in waters at least 79°F (26°C), restricting their habitat primarily to the tropics (Eckert, 2002; Sarti-Martinez, 2000). Other than a general association with warm waters, the distribution of hatchling and early juvenile leatherbacks is not known. Upwelling areas, such as equatorial convergence zones, are nursery grounds for hatchling and early juvenile leatherbacks, because these areas provide a good supply of prey (Musick and Limpus, 1997). Individuals with a curved shell length of less than 57 inches (145 cm) are considered to be juveniles (Eckert, 2002; NMFS, 2001).

Leatherbacks are likely the fastest developing of all sea turtle species, reaching adulthood at 13 to 14 years (range 2 to 22 years) (Turtle Expert Working Group, 2007; Zug and Parham, 1996), and can live to 30 years or more (Sarti-Martinez, 2000). Throughout their lives, leatherbacks are essentially oceanic, yet they enter coastal waters to forage and reproduce (NMFS and USFWS, 1992). The species is not typically associated with coral reefs, but is occasionally encountered in deep ocean waters near prominent island chains, such as deep waters off the Hawaiian Island chain (Eckert, 1993). There is evidence that leatherbacks are associated with oceanic front systems, such as shelf breaks and the edges of oceanic gyre systems, where their prey is concentrated (Eckert, 1993).

The leatherback's unique anatomy and metabolism, compared to all other turtle species (Bradshaw et al., 2007; Goff and Stenson, 1988; Greer et al., 1973; Mrosovsky and Pritchard, 1971; Neill and Stevens, 1974; Paladino et al., 1990), allows them to maintain a core body temperature higher than that of the surrounding water, thereby allowing them to tolerate colder waters (Frair et al., 1972; James and Mrosovsky, 2004). As juveniles grow, this ability is enhanced, allowing leatherbacks to expand their ranges into the cooler waters (Eckert, 2002).

Nesting leatherbacks prefer wide sandy beaches backed with vegetation (Eckert, 1987; Hirth and Ogren, 1987). In the water, they prefer habitat characterized by steep drop-offs or mud banks without coral or rock formations (Turtle Expert Working Group, 2007). For both the Western and Eastern Pacific subpopulations, the nesting season extends from October through March, with a peak in December. The Jamursba-Medi (Papua) stock is an exception, nesting from April to October, with a peak in August (Chaloupka et al., 2004). Typical clutches are 50 to more than 150 eggs, with the incubation period lasting around 65 days. Females lay an average of five to seven clutches in a single season (with a maximum of 11) with intervals of 8 to 10 days or longer (NMFS and USFWS, 1992). Females remain in the general vicinity of the nesting habitat for their breeding period, which can last up to four months (Eckert, Eckert, Adams et al., 1989; Keinath and Musick, 1993), although they may nest on several islands in a chain during a single nesting season (Pritchard, 1982). Mating is thought to occur before or during the migration from temperate to tropical waters (Eckert and Eckert, 1988).

Predator and Prey Interactions

Leatherbacks lack the crushing and chewing plates characteristic of other sea turtle species that feed on hard-bodied prey (NMFS, 2010b). Instead, they have pointed tooth-like cusps and sharp-edged jaws that are used for consuming soft-bodied prey such as jellyfish and salps (Bjorndal, 1997; Grant and Ferrell, 1993; James and Herman, 2001; NMFS and USFWS, 1992; Salmon et al., 2004). Leatherbacks feed at the surface and at depth, diving to 4,035 feet (1,240 m) (Davenport, 1988; Eckert, Eckert, Poganis et al., 1989; Eisenberg and Frazier, 1983; Grant and Ferrell, 1993; Hays et al., 2004b; James et al., 2005; Salmon et al., 2004). Leatherbacks in the Caribbean may synchronize their diving patterns with the daily vertical migration of a deep-water ecosystem of fishes, crustaceans, gelatinous salps, and siphonophores, known as the deep scattering layer, which moves toward the surface of the ocean at dusk and descends at sunrise (Eckert et al., 1989; Eckert, Eckert, Poganis et al., 1986). A similar vertical migration of small fish and crustacean species has been studied in the Insular Pacific-Hawaiian Large Marine Ecosystem, which migrates from approximately 1,300 to 2,300 feet (396 to 701 m) during the day to near the surface at night (Benoit-Bird et al., 2001). It is unknown whether this type of foraging is widespread for leatherbacks (Eckert, Eckert, Poganis et al., 1989). Leatherbacks on known feeding grounds have been observed foraging on jellyfish at the surface (Grant and Ferrell, 1993; James and Herman, 2001; Starbird et al., 1993). Leatherbacks are subject to predation by the same predators as other sea turtles, such as sharks, certain fish preying on hatchlings, and various land predators preying on hatchlings (e.g., ants, crabs, birds, and mammals) (NMFS and USFWS, 2007c).

4.0 Determination of Effects

Marine mammals and sea turtles could potentially be impacted during Long Range Strike WSEP mission activities by munition strikes, ingestion of military expended materials, and detonation effects (overpressure and acoustic components). Each of these potential stressors is discussed in the following subsections.

4.1 Marine Mammals

Potential impacts to marine mammals resulting from Long Range Strike WSEP activities, including physical strike, ingestion stressors, and detonation effects (overpressure and acoustic components), are discussed in the following subsections.

4.1.1 Physical Strike

Marine mammals could be physically struck by weapons during Long Range Strike WSEP missions. A total of only nine weapons (one JASSM and eight SDBs) will be released during the first year of testing. Over the following five years, 550 bombs and missiles will be deployed, for an average of 110 per year. In each year, all weapons will be deployed in summer. The velocity of bombs, missiles, and other munitions decreases quickly after striking the water, and therefore injury and mortality are considered unlikely for animals swimming in the water column at a depth of more than a few meters. Strike potential would generally be limited to animals located at the water surface or in the water column near the surface, and would be affected by factors such as size and relative speed of the munition. Strike potential would be reduced by pre-mission surveys, avoidance of observed marine mammals in the mission area, and the generally dispersed distribution of marine mammals. Although the probability of a direct strike by test weapons is not quantified, the Air Force considers it to be low.

The Air Force considers the potential for direct strike resulting from Long Range Strike WSEP missions **may affect, but are not likely to adversely affect** marine mammal species protected under the ESA.

4.1.2 Ingestion Stressors

Military expended materials that would be produced during Long Range Strike WSEP missions include inert munitions and fragments of exploded bombs and missiles. Intact, inert munitions would be too large to ingest. However, some munition fragments could be ingested by some species, possibly resulting in injury or death.

A small quantity of exploded weapons components could float on the surface. Species feeding at the surface could incidentally ingest these floating items. Sei whales are known to skim feed, and there is potential for other species to feed at the surface. Laist (1997) provides a review of numerous marine mammal species that have been documented to ingest debris, including 21 odontocetes. Most of these species had apparently ingested debris floating at the surface. A marine mammal would suffer a negative impact from military expended materials if the item becomes imbedded in tissue or is too large to pass through the digestive system. Some of the items would be small enough to pass through an animal’s digestive system without harm. In addition, an animal would not likely ingest every expended item it encountered. The number of items at the surface encountered by a given animal would be decreased by the low initial density of items and dispersal by currents and wind. Due to the small amount of floating military expended materials produced and the dispersed nature of marine mammals and marine mammal groups potentially encountering an item at the surface, floating military expended materials are unlikely to negatively affect marine mammals.

Most military expended materials would not remain on the water surface but would sink at various rates of speed, depending on the density and shape of the item. Individual marine mammals feeding in the water column (for example, dolphins preying on fish or squid at middle depths) could potentially ingest a sinking item. Most items would sink relatively quickly and would not remain suspended in the water column indefinitely. In addition, not all items encountered would be ingested, as a marine mammal would probably be able to distinguish military expended materials from prey in many instances. Overall, sinking items are not expected to present a substantial ingestion threat to marine mammals.

Most of the military expended materials resulting from Long Range Strike WSEP missions would sink to the bottom and would probably eventually become encrusted and/or covered by sediments, although cycles of covering/exposure could occur due to water currents. Munition fragments would sink relatively quickly to the substrate. Several marine mammal species feed at or near the seafloor. For example, although sperm whales feed primarily on squid (presumably deep in the water column), demersal fish species are also sometimes consumed. Humpback whales may also feed near the bottom, and beaked whales use suction feeding to ingest benthic prey. Hawaiian monk seals feed on numerous species that may occur on or near the seafloor, including fish, cephalopods, and lobsters. Therefore, there is some potential for such species to incidentally ingest military expended materials while feeding. However, the potential for such encounters is low based on the relatively low number and patchy distribution of the items produced, the patchy distribution of marine mammal feeding habitat, and water depth at the impact location (over 4,000 meters). Further, an animal would not likely ingest every military expended material it encounters. Animals may attempt to ingest an item and then reject it after realizing it is not a food item. Additionally, ingestion of an item would not necessarily result in injury or mortality to the individual if the item does not become embedded in tissue (Wells et al., 2008). Therefore, impacts resulting from ingestion of military expended materials would be limited to the unlikely event where a marine mammal suffers a negative response from ingesting an item that becomes embedded in tissue or is too large to pass through the digestive system. Military expended materials that become encrusted or covered by sediments would have a lower potential for ingestion. In general, it is not expected that large numbers of items on the seafloor would be consumed and result in harm to marine mammals, particularly given the water depth at the impact location.

In summary, it is possible that military expended materials could be ingested by marine mammals and cause behavioral impacts, injury, decreased feeding ability, or death. Based on the discussion above, the Air Force considers that a small number of impacts could occur, and population-level effects on any species are considered unlikely. Therefore, ingestion of military expended materials **may affect, but is not likely to adversely affect**, marine mammal species protected under the ESA.

4.1.3 Detonation Effects

Cetaceans spend their entire lives in the water and are submerged below the surface much of the time. When at the surface, unless engaging in behaviors such as jumping, spyhopping, etc., the body is almost entirely below the water's surface, with only the blowhole exposed to allow breathing. This can make cetaceans difficult to locate visually and also exposes them to underwater noise, both natural and anthropogenic, most of the time because their ears are nearly always below the water's surface. Hawaiian monk seals spend some portion of their time out of the water. However, when swimming under the surface (e.g., during foraging dives), seals are also exposed to natural and anthropogenic noise. As a result, marine mammals located near a surface detonation could be exposed to the resulting shock wave and acoustic energy. Potential effects include mortality, injury, impacts to hearing, and behavioral disturbance.

The potential numbers and species of marine mammals taken are assessed in this section. Appendix A provides a description of the acoustic modeling methodology used to estimate exposures, as well as the model outputs. Three sources of information are necessary for estimating potential detonation effects on marine mammals: (1) the zone of influence, which is the distance from an explosion to which particular levels of impact would extend; (2) the density of animals within the zone of influence; and (3) the number of detonations (events). Each of these components is described in the following subsections.

Zone of Influence

The zone of influence is defined as the area or volume of ocean in which marine mammals could be exposed to various pressure or acoustic energy levels caused by exploding ordnance. Refer to Appendix A for a description of the method used to calculate impact volumes for explosives. The pressure and energy levels considered to be of concern are defined in terms of metrics, criteria, and thresholds. A *metric* is a technical standard of measurement that describes the acoustic environment (e.g., frequency duration, temporal pattern, and amplitude) and pressure at a given location. *Criteria* are the types of possible effects and include mortality, injury, and harassment. A *threshold* is the level of pressure or noise above which the impact criteria are reached. The analysis of potential impacts to marine mammals incorporates criteria and thresholds presented in Finneran and Jenkins (2012). The paragraphs below provide a general discussion of the various metrics, criteria, and thresholds used for impulsive noise impact assessment. More detailed information is provided in Appendix A.

Metrics

Standard impulsive and acoustic metrics were used for the analysis of underwater energy and pressure waves in this document. Several different metrics are important for understanding risk assessment analysis of impacts to marine mammals.

***SPL* (sound pressure level):** A ratio of the absolute sound pressure and a reference level. Units are in decibels referenced to 1 micropascal (i.e., dB re 1 μPa).

***SEL* (sound exposure level):** SEL is a measure of sound intensity and duration. When analyzing effects on marine animals from multiple moderate-level sounds, it is necessary to have a metric that quantifies cumulative exposures. SEL can be thought of as a composite metric that represents both the intensity of a sound and its duration. SEL is determined by calculating the decibel level of the cumulative sum-of-squared pressures over the duration of a sound, with units of decibels referenced to 1 micropascal-squared seconds (dB re 1 $\mu Pa^2 \cdot s$) for sounds in water.

Positive impulse: This is the time integral of the pressure over the initial positive phase of an arrival. This metric represents a time-averaged pressure disturbance from an explosive source. Units are typically pascal-seconds (Pa·s) or pounds per square inch per millisecond (psi·msec). There is no decibel analog for impulse.

Criteria and Thresholds

The criteria and thresholds used to estimate potential pressure and acoustic impacts to marine mammals resulting from detonations were obtained from Finneran and Jenkins (2012) and include mortality, injurious harassment (Level A), and non-injurious harassment (Level B). In some cases, separate thresholds have been developed for different species groups or functional hearing groups. Functional hearing groups included in the analysis are low-frequency cetaceans, mid-frequency cetaceans, high frequency cetaceans, and phocids. A more detailed description of each of the criteria and thresholds is provided in Appendix A.

Mortality

Mortality risk assessment may be considered in terms of direct injury, which includes primary blast injury and barotrauma. The potential for direct injury of marine mammals has been inferred from terrestrial mammal experiments and from post-mortem examination of marine mammals believed to have been exposed to underwater explosions (Finneran and Jenkins, 2012; Ketten et al., 1993; Richmond et al., 1973). Actual effects on marine mammals may differ from terrestrial animals due to anatomical and physiological differences, such as a reinforced trachea and flexible thoracic cavity, which may decrease the risk of injury (Ridgway and Dailey, 1972).

Primary blast injuries result from the initial compression of a body exposed to a blast wave, and is usually limited to gas-containing structures (e.g., lung and gut) and the auditory system (U.S. Department of the Navy, 2001b). Barotrauma refers to injuries caused when large pressure changes occur across tissue interfaces, normally at the boundaries of air-filled tissues such as the lungs. Primary blast injury to the respiratory system may be fatal depending upon the severity of the trauma. Rupture of the lung may introduce air into the vascular system, producing air emboli that can restrict oxygen delivery to the brain or heart.

Whereas a single mortality threshold was previously used in acoustic impacts analysis, species-specific thresholds are currently required. Thresholds are based on the level of impact that would cause extensive lung injury resulting in mortality to 1 percent of exposed animals (that is, an impact level from which 1 percent of exposed animals would not recover) (Finneran and Jenkins, 2012). The threshold represents the expected onset of mortality, where 99 percent of exposed animals would be expected to survive. Most survivors would have moderate blast injuries. The lethal acoustic level of a blast, associated with the positive impulse pressure of the blast, is expressed as Pa·s and is determined using the Goertner (1982) modified positive impulse equation. This equation incorporates source/animal depths and the mass of a newborn calf for the affected species. The threshold is conservative because animals of greater mass can withstand greater pressure waves, and newborn calves typically make up a very small percentage of any marine mammal group. While the mass of newborn calves for some species are provided in literature, in many cases this information is unknown and a surrogate species (considered to be generally comparable in mass) is used instead. Finneran and Jenkins (2012) provide known or surrogate masses for newborn calves of several cetacean species. The Goertner equation, as presented in Finneran and Jenkins (2012), is used in the acoustic model to develop impacts analysis in this document. The equation is provided in Appendix A.

Injury (Level A Harassment)

Three categories of blast-related injury (Level A harassment) are currently recognized by NMFS: gastrointestinal (GI) tract injury, slight lung injury, and irrecoverable auditory damage (permanent threshold shift).

Gastrointestinal Tract Injuries. Though often secondary in life-threatening severity to pulmonary blast trauma, the GI tract can also suffer contusions and lacerations from blast exposure, particularly in air-containing regions of the tract. Although hemorrhage of solid organs (e.g., liver, spleen, and kidney) from blast exposure is possible, rupture of these organs is rarely encountered. GI tract injuries are correlated with the peak pressure of an underwater detonation. GI tract injury thresholds are based on the results of experiments in the 1970s in which terrestrial mammals were exposed to small charges. The peak pressure of the shock wave was found to be the causal agent in recoverable contusions (bruises) in the GI tract (Richmond et al., 1973, in Finneran and Jenkins, 2012). The experiments found that a peak SPL of 237 dB re 1 μPa predicts the onset of GI tract injuries, regardless of an animal's mass or size. Therefore, the unweighted peak SPL of 237 dB re 1 μPa is used in explosive impacts assessments as the threshold for slight GI tract injury for all marine mammals.

Slight Lung Injury. This threshold is based on a level of exposure where most animals may experience slight blast injury to the lungs, but all would survive (zero percent mortality) (Finneran and Jenkins, 2012). Similar to the mortality determination, the metric is positive impulse and the equation for determination is that of the Goertner injury model (1982), corrected for atmospheric and hydrostatic pressures and based on the cube root scaling of body mass (Richmond et al., 1973; U.S. Department of the Navy, 2001b). The equation is provided in Appendix A.

Auditory Damage (Permanent Threshold Shift). Another type of injury correlated to Level A harassment is permanent threshold shift (PTS), which is auditory damage that does not recover and results in a permanent decrease in hearing sensitivity. There have been no studies to determine the onset of PTS in marine mammals and, therefore, this threshold must be estimated from other available information.

Finneran and Jenkins (2012) define separate PTS thresholds for three groups of cetaceans based on hearing sensitivity (low-frequency, mid-frequency, and high-frequency), and for phocids. Dual criteria are provided for PTS thresholds, one based on the SEL and one based on the SPL of an underwater blast. For a given analysis, the more conservative of the two is typically applied to afford the most protection to marine mammals. The PTS thresholds are provided in Appendix A.

Non-Injurious Impacts (Level B Harassment)

Two categories of non-injurious Level B harassment are currently recognized: temporary threshold shift (TTS) and behavioral impacts. Although TTS is a physiological impact, it is not considered injury because auditory structures are temporarily fatigued instead of being permanently damaged.

Temporary Threshold Shift. Non-injurious effects on marine mammals, such as TTS, are generally extrapolated from data on terrestrial mammals (Southall et al., 2007). Similar to PTS, dual criteria are provided for TTS thresholds, and the more conservative is typically applied in impacts analysis. TTS criteria are based on data from impulse sound exposures when available. If impulse TTS data are not available, data from non-impulse exposures may be used (adjusted for the relationship between impulse and non-impulse TTS observed in dolphins and belugas). For species where no data exist, TTS thresholds are based on the most closely related species for which data are available. The TTS thresholds are provided in Appendix A.

Behavioral Impacts. Behavioral impacts refer to disturbances that may occur at acoustic levels below those considered to cause TTS in marine mammals, particularly in cases of multiple detonations. During an activity with a series of explosions (not concurrent multiple explosions), an animal is expected to exhibit a startle reaction to the first detonation followed by a behavioral response after multiple detonations. At close ranges and high sound levels, avoidance of the area around the explosions is the assumed behavioral response in most cases. Behavioral impacts may include decreased ability to feed, communicate, migrate, or reproduce, among others. Such effects, known as sub-TTS Level B harassment, are based on observations of behavioral reactions in captive dolphins and beluga whales exposed to pure tones, a different type of sound than that produced from an underwater detonation (Finneran and Schlundt, 2004; Schlundt et al., 2000). Behavioral effects are generally considered to occur when animals are exposed to multiple, successive detonations at the same location within a 24-hour period. For single detonations, behavioral disturbance is likely limited to short-term startle reactions. The behavioral impacts thresholds for marine mammals exposed to multiple, successive detonations are provided in Appendix A.

4.1.4 Marine Mammal Density

For purposes of impacts analysis, the number of marine mammals potentially affected may be considered in terms of density, which is the number of animals present in the area affected by a given surface detonation. A significant amount of effort is required to collect and analyze survey data sufficient for producing useable marine species density estimates for large areas such as the HRC, and is typically beyond the scope of any single organization. As a result, there is often no single source of density available for every area, species, and season of interest; density data are often compiled from multiple sources. The density estimates used for acoustic analysis in this document are from the U.S. Navy's Marine Species Density Database for the Pacific region, which includes the HRC (U.S. Department of the Navy, 2014). The Navy database includes a compilation of the best available density data from several primary sources and published works, including NMFS survey data within the Hawaiian Islands EEZ. NMFS publishes annual stock assessment reports for various regions of U.S. waters, which cover all stocks of marine mammals within those waters (for abundance and distribution information of species potentially occurring within the study area, see Allen and Angliss [2014], Carretta et al. [2015], and Bradford et al. [2015]). Other researchers often publish density data or research covering a particular marine mammal species or geographic area, which is integrated into the stock assessment reports.

For most marine mammal species, abundance is estimated using line-transect methods that derive densities based on sighting data collected during systematic ship or aerial surveys. Habitat-based models may also be used to model density as a function of environmental variables. Each source of data may use different methods to estimate density, and uncertainty in the estimate can be directly related to the method applied. Uncertainty in published density estimation is typically large because of the low number of sightings collected during surveys. Uncertainty characterization is an important consideration in marine mammal density estimation and some methods inherently result in greater uncertainty than others. Therefore, in selecting the best density value for a species, area, and time, it is important to select the data source that used a method that provides the least uncertainty and the best estimate for the geographic area. A discussion of methods that provide the best estimate with the least uncertainty under different scenarios is provided in the Navy's density database technical report (U.S. Department of the Navy, 2014). For this analysis, the Navy provided their most recent information on the type of model used to estimate density, along with the sources of uncertainty (expressed as a coefficient of variation), for each marine mammal species in the Hawaii region as part of their latest updates to the Navy Marine Species Density Database (NMSDD). At the time of writing this BA, the latest technical report for the updated NMSDD was still under development, so the source documents for the coefficient of variation values may be more recent than the currently available NMSDD technical report referenced above. The most recent information is reproduced in Table 4-1.

Table 4-1. Marine Mammal Density Models and Uncertainty Values for the Hawaii Region

Species	Coefficient of Variation	Source	Model Type
Humpback whale	Main: 0.15 Outer strata and transit boxes: 0.30	Main Hawaii Islands inner stratum: Mobley et al. (2001b) Outer strata and transit boxes: Calambokidis et al. (2008)	Main Hawaii Islands: line-transect Outer EEZ: mark-recapture
Blue whale	1.09	Bradford et al. (in review)	Multiple-covariate line-transect
Fin whale	1.05	Bradford et al. (in review)	Multiple-covariate line-transect
Sei whale	0.90	Bradford et al. (in review)	Multiple-covariate line-transect
Sperm whale	Spatially-explicit	Forney et al. (2015)	Habitat-based density model
False killer whale (Main Hawaiian Islands Insular stock)	0.20	Oleson et al. (2010)	Population Viability Analysis
Hawaiian monk seal	n/a	n/a	Navy derived

n/a = not available; EEZ = Exclusive Economic Zone

The NMSDD is considered the most relevant information source available for the Hawaii area, and has been endorsed by NMFS for use in impacts analysis of previous military actions conducted near the Study Area. For some species, density estimates are uniform throughout the Hawaii region. For others, densities are provided in multiple, smaller blocks. In these cases, the Air Force used density estimates corresponding to the block containing the Long Range Strike WSEP impact location. The resulting marine mammal seasonal density estimates used in this document are shown in Table 4-2. Long Range Strike WSEP missions are generally planned to occur in summer, and summer densities (June to August) are therefore considered most applicable.

Table 4-2. Marine Mammal Density Estimates

Species	Density Estimate (animals per square kilometer)			
	Fall	Spring	Summer	Winter
Humpback whale	0.02110	0.02110	0	0.02110
Blue whale	0.00005	0.00005	0	0.00005
Fin whale	0.00006	0.00006	0	0.00006
Sei whale	0.00016	0.00016	0	0.00016
Sperm whale	0.00156	0.00156	0.00156	0.00156
False killer whale (Main Hawaiian Islands insular stock)	0.00080	0.00080	0.00080	0.00080
Hawaiian monk seal	0.00003	0.00003	0.00003	0.00003

Density is typically reported for an area (e.g., animals per square kilometer). Density estimates usually assume that animals are uniformly distributed within the affected area, even though this is rarely true. Marine mammals may be clumped in areas of greater importance; for example, animals may be more concentrated in areas offering high productivity, lower predation, safe calving, etc. However, because there are usually insufficient data to calculate density for small areas, an even distribution is typically assumed for impact analyses.

Although the Study Area is depicted as only the surface of the water, in reality, density implicitly includes animals anywhere within the water column under that surface area. Assuming that marine mammals are distributed evenly within the water column does not accurately reflect animal behaviors. Databases of behavioral and physiological parameters obtained through tagging and other technologies have demonstrated that marine animals use the water column in various ways. Some species conduct regular deep dives while others engage in much shallower dives, regardless of bottom depth. The depth distribution for each species included in the Study Area is provided in Appendix B. Combining marine mammal density with depth information would allow impact estimates to be based on three-dimensional density distributions, likely resulting in more accurate modeling of potential exposures. However, based on current regulatory guidance, density is assumed to be two-dimensional, and exposure estimates are therefore simply calculated as the product of affected area, animal density, and number of events. The resulting exposure estimates are considered conservative because all animals are presumed to be located at the same depth, where the maximum sound and pressure ranges would extend from detonations and would therefore be exposed to the maximum amount of energy or pressure. In reality, it is highly likely that some portion of marine mammals present near the impact area at the time of detonation would be at various depths in the water column and not necessarily occur at the same depth corresponding to the maximum sound and pressure ranges.

4.1.5 Number of Events

An "event" refers to a single, unique action that has the potential to expose marine mammals to pressure and/or noise levels associated with take under the MMPA. For Long Range Strike WSEP activities, the number of events generally corresponds to the number of live ordnance items released within a 24-hour period. For 2016 missions, all live ordnance being released (Table 2-2) are proposed to occur on the same mission day, which would equate to a single event with multiple releases. Up to four SDBs may be released simultaneously and would detonate within a few seconds of each other in the same vicinity and is referred to as a "burst". Under such a detonation scenario, the energy from all four munitions in the burst is summed, but the pressure component is not. For 2016 missions, one JASSM/JASSM-ER release and two SDB-I bursts (eight total SDB-I munitions) releases are proposed. The JASSM/JASSM/ER release would occur separately from each SDB-I burst release but the total energy for all releases in a 24-hour period is summed for impact calculations. For 2017–2021, the exact number and type of munitions that would be released each day is not known and would vary. To account for total annual impacts, the total number of each munition proposed to be released per year was divided by five (annual number of mission days), which was treated as a representative mission day. Consistent with the 2016 mission approach, the total energy for all weapon releases as part of a representative mission day is summed for impact calculations. Unlike 2016, there will be a total of five mission days per year during the time frame of 2017–2021. Refer to Appendix A for a detailed explanation of modeling methods.

4.1.6 Exposure Estimates

The maximum estimated range, or radius, from the detonation point to which the various thresholds extend for all munitions proposed to be released in a 24-hour time period was calculated based on explosive acoustic characteristics, sound propagation, and sound transmission loss in the Study Area, which incorporates water depth, sediment type, wind speed, bathymetry, and temperature/salinity profiles (Table 4-3). Ranges are provided separately for the 2016 and 2017–2021 missions, based on muntions expected to be released during the representative mission day. The ranges were used to calculate the total area (circle) of the zones of influence for each criterion/threshold. To eliminate "double-counting" of animals, impact areas from higher impact categories (e.g., mortality) were subtracted from areas associated with lower impact categories (e.g., Level A harassment). The estimated number of marine mammals potentially exposed to the various impact thresholds was then calculated as the product of the adjusted impact area, animal density, and number of events per year. Since the acoustic model accumulates the energy from all detonations within a 24-hour timeframe, it is assumed that the same population of animals is being impacted within that time period. The population would refresh after 24 hours. Since five mission days are planned annually for 2017–2021, take estimates from the representative mission day were multiplied by five to determine the total annual numbers of take. Details of the acoustic modeling method are provided in Appendix A. For metrics with multiple criteria (e.g., slight lung injury, GI tract injury, and PTS for Level A Harassment) and criteria with two thresholds (e.g., 187 dB SEL and 230 peak SPL for PTS), the criterion and/or threshold that results in the higher exposure estimate is presented in the table and used for impact calculations.

Missions Conducted in 2016

Immediate evaluations for JASSM/JASSM-ER and SDB I/II are needed for a smaller number of munitions in 2016, compared to the level of activities proposed for 2017–2021. Therefore, the potential impacts resulting from 2016 evaluations are discussed separately. Weapon release parameters for the 2016 mission would involve the release of one live JASSM and eight live SDB-I. As described previously, up to four SDB-I/II munitions would be released simultaneously; however the SDB-I releases would occur separately from the JASSM. The resulting total number of marine mammals potentially exposed to the various levels of thresholds from 2016 missions is shown in Table 4-4. An animal is considered "exposed" to a sound if the received sound level at the animal's location is above the background ambient acoustic level within a similar frequency band.

The model output resulted in calculations of zero exposures for baleen whales due to the absence of these species during the summer/early fall. For the remaining species (sperm whale and Hawaiian monk seal), exposure calculations from the model output resulted in decimal values, suggesting that a fraction of an animal was exposed. To eliminate this, the acoustic model results were rounded to the nearest whole animal to obtain the exposure estimates from 2016 missions. Furthermore, to eliminate "double-counting" of animals, exposure results from higher impact categories (e.g., mortality) were subtracted from lower impact categories (e.g., Level A harassment).

The results indicate that there would be no exposures of ESA-listed marine mammals in the Study Area for any criterion. Based on the analysis presented above, the Air Force considers that detonation impacts from Long Range Strike WSEP missions proposed for 2016 **may affect, but are not likely to adversely affect** marine mammal species protected under the ESA.

Table 4-3. Threshold Radii (in meters) for Long Range WSEP Missions

Mission Scenario	Mortality	Level A Harassment				Level B Harassment		
		Slight Lung Injury	GI Tract Injury	PTS		TTS		Behavioral
	Based on Goertner (1982)	Based on Richmond et al. (1973)	237 dB SPL	Applicable SEL*	Applicable SPL*	Applicable SEL*	Applicable SPL*	Applicable SEL*
Humpback Whale								
2016 Mission	38	81	165	2,161	330	6,565	597	13,163
2017–2021 Typical Mission Day	99	200	204	3,744	413	13,836	763	56,233
Blue Whale								
2016 Mission	28	59	165	2,161	330	6,565	597	13,163
2017–2021 Typical Mission Day	74	149	204	3,744	413	13,836	763	56,233
Fin Whale								
2016 Mission	28	62	165	2,161	330	6,565	597	13,163
2017–2021 Typical Mission Day	76	157	204	3,744	413	13,836	763	56,233
Sei Whale								
2016 Mission	38	83	165	2,161	330	6,565	597	13,163
2017–2021 Typical Mission Day	101	204	204	3,744	413	13,836	763	56,233
Sperm Whale								
2016 Mission	33	72	165	753	330	3,198	597	4,206
2017–2021 Typical Mission Day	91	177	204	1,290	413	7,016	763	10,648
False Killer Whale (MHI)								
2016 Mission	72	153	165	753	330	3,198	597	4,206
2017–2021 Typical Mission Day	206	340	204	1,290	413	7,016	763	10,648
Hawaiian Monk Seal								
2016 Mission	135	256	165	1,452	1,107	3,871	1,881	6,565
2017–2021 Typical Mission Day	306	564	204	3,267	1,394	10,539	2,549	51,690

dB = decibel; GI = gastrointestinal; MHI = Main Hawaiian Islands Insular stock; PTS = permanent threshold shift; SEL = sound exposure level; SPL = sound pressure level; TTS = temporary threshold shift
*Based on the applicable Functional Hearing Group

Table 4-4. Number of Marine Mammals Potentially Affected by Long Range Strike WSEP Missions (2016)

Species	Mortality (Criterion)	Level A Harassment (PTS)	Level B Harassment (TTS)	Level B Harassment (Behavioral)
Mysticetes (baleen whales)				
Humpback whale	0	0	0	0
Blue whale	0	0	0	0
Fin whale	0	0	0	0
Sei whale	0	0	0	0
Odontocetes (toothed whales and dolphins)				
Sperm whale	0	0	0	0
False killer whale (MHI)	0	0	0	0
Pinnipeds				
Hawaiian monk seal	0	0	0	0

MHI = Main Hawaiian Islands Insular stock; PTS = permanent threshold shift; TTS = temporary threshold shift

Missions Conducted from 2017 to 2021

As previously discussed, proposed munition releases for 2017–2021 missions are greater than what is proposed for 2016 missions. The total number of ESA-listed marine mammals potentially exposed as a result of missions conducted from 2017 to 2021 is shown in Table 4-5. Similar to the modeling results for 2016, the exposure calculations resulted in decimal values, suggesting in most cases that a fraction of an animal was exposed. To eliminate this, the acoustic model results were rounded to the nearest whole animal. Furthermore, to eliminate "double-counting" of animals, exposure results from higher impact categories (e.g., mortality) were subtracted from lower impact categories (e.g., Level A harassment). For impact categories with multiple criteria and/or thresholds (e.g., three criteria and four thresholds associated with Level A harassment), numbers in the table are based on the threshold resulting in the greatest number of exposures. A variety of effects may result from exposure to sound-producing activities. The severity of the effects can range from minor effects with no real cost to the animal to more severe effects that may have lasting consequences. Exposure levels include the possibility of non-injurious harassment (TTS and behavioral harassment) to a small number of marine mammals. The numbers represent total annual impacts for all detonations combined. These exposure estimates do not take into account the required mitigation and monitoring measures described in Section 5 of this document, which may decrease the potential for impacts.

Table 4-5. Number of Marine Mammals Potentially Affected by Long Range Strike WSEP Missions (2017–2021)

Species	Mortality (Criterion)	Level A Harassment (PTS)	Level B Harassment (TTS)	Level B Harassment (Behavioral)
Mysticetes (baleen whales)				
Humpback whale	0	0	0	0
Blue whale	0	0	0	0
Fin whale	0	0	0	0
Sei whale	0	0	0	0
Odontocetes (toothed whales and dolphins)				
Sperm whale	0	0	1	2
False killer whale (MHI)	0	0	1	1
Pinnipeds				
Hawaiian monk seal	0	0	0	1
Total[1]	**0**	**0**	**2**	**4**

MHI = Main Hawaiian Islands Insular stock; PTS = permanent threshold shift; TTS = temporary threshold shift
[1]Number of animals impacted by higher thresholds subtracted from less impactive thresholds.

Based on acoustic modeling, there would be no marine mammals affected by impulse pressure or energy levels associated with mortality or injury (Level A harassment). Modeling results indicate that two marine mammals (one sperm whale and one false killer whale) could potentially be exposed to non-injurious (TTS) Level B harassment. Auditory fatigue is a reduction in hearing ability resulting from overstimulation to sounds that may result from damage or distortion of the tympanic membrane and hair cells, hair cell death, changes in cochlear blood flow, and cochlear nerve swelling. The distinction between PTS and TTS is based on whether there is complete recovery of hearing sensitivity following a sound exposure. If the animal's hearing ability eventually returns to pre-exposure levels, the threshold shift is considered temporary. Studies of terrestrial mammals show that large amounts of TTS (approximately 40 dB measured 24 hours after exposure) can result in permanent neural degeneration, despite the hearing thresholds returning to normal. Animals are most susceptible to auditory fatigue within their most sensitive hearing range. The greater the degree of threshold shift, the smaller the ocean space within which an animal can detect biologically relevant sounds. In this document, the threshold resulting in the highest exposure estimates was used to determine takes. The SEL metrics result in higher exposure estimates compared with peak SPL metrics and are conservatively used for impacts analysis.

A total of four marine mammals could potentially be exposed to sound corresponding to applicable Level B behavioral thresholds during Long Range Strike WSEP missions. Of this total, exposures are calculated for two sperm whales, one false killer whale (Main Hawaiian Islands Insular stock), and one Hawaiian monk seal. Behavioral harassment occurs at distances beyond the range of structural damage and hearing threshold shift. Numerous behavioral responses can result from physiological responses. An animal may react to a stimulus based on a number of factors in addition to the severity of the physiological response. An animal's previous experience with the same or a similar sound, the context of the exposure, and the presence of other stimuli contribute to determining its reaction. Behavioral responses fall into two major categories: alterations in natural behavior patterns and avoidance. These types of reactions are not mutually exclusive, and overall reactions may be combinations of behaviors or a sequence of behaviors. Severity of behavioral reactions can vary substantially, from minor and brief reorientations of the animal to investigate the sound to severe reactions such as aggression or prolonged flight. The type and severity of the behavioral response will determine the energetic cost to the animal. Possible behavioral responses to a detonation include panic, startle, departure from an area, and disruption of activities such as feeding or breeding, among others.

The magnitude and type of effect, as well as the speed and completeness of recovery, affect the long-term consequences to individual animals and populations. Animals that recover quickly and completely from explosive effects will not likely suffer reductions in their health or reproductive success, or experience changes in their habitat utilization. In such cases, no population-level effects would be expected. Animals that do not recover quickly and fully could suffer reductions in their health and reproductive success; they could be permanently displaced or change how they utilize the environment; or they could die. Frequent disruptions to natural behavior patterns may not allow an animal to fully recover between exposures, which increases the probability of causing long-term consequences to individuals. Long-term consequences to individuals can lead to population level consequences.

As described in the associated request for a Letter of Authorization, consideration of "negligible impact" is required by NMFS to authorize incidental take of marine mammals. An activity has a negligible impact on a species or stock when it is determined that the total taking is not likely to reduce annual rates of adult survival or recruitment (offspring survival, birth rates). The only type of potential impact associated with the proposed activities is TTS and behavioral effects (Level B harassment). Behavioral reactions of marine mammals to sound are known to occur but are difficult to predict. Behavioral studies indicate that reactions to sounds, if any, are highly contextual and vary between species and individuals within a species (Moretti et al., 2010; Southall et al., 2011; Thompson et al., 2010; Tyack, 2009a; Tyack et al., 2011). Depending on the context, marine mammals often change their activity when exposed to disruptive levels of sound. For example, when sound becomes potentially disruptive, cetaceans at rest become active and feeding or socializing cetaceans or pinnipeds often interrupt these events by diving or swimming away. Recent studies on the effects of active sonar (a non-impulsive sound) on marine mammals have been undertaken within the PMRF. Martin et al. (2015) found that the number of minke whale calls detected on the range's hydrophones decreased with the use of active sonar (time frame of 2011 to 2013). Blainville's beaked whales underwent fewer dives during sonar use compared to periods without sonar use, and there is some indication that individuals moved toward the edges of the range (Martin et al., 2016). Conversely, Baird et al. (2014) investigated movements of satellite-tagged bottlenose dolphins, short-finned pilot whales, and rough-toothed dolphins exposed to active sonar and found no indication of large-scale movement away from the sound, although the authors note some limitations in the study. If sound disturbance occurs around a haul out site, pinnipeds may move back and forth between water and land or eventually abandon the site. When attempting to understand behavioral disruption by anthropogenic sound, a key consideration is whether the exposures have biologically significant consequences for the individual or population (National Research Council, 2005).

If a marine mammal does react to an underwater sound by changing its behavior or moving a small distance, the impacts of the change may not be important to the individual. For example, researchers have found during a study of dolphins response to whale watching vessels in New Zealand that when animals can cope with constraint and easily feed or move elsewhere, there is little effect on survival (Lusseau and Bejder, 2007). On the other hand, if a sound source displaces marine mammals from an important feeding or breeding area for a prolonged period and they do not have an alternate equally desirable area, impacts on the marine mammal could be negative because the disruption has biological consequences. Biological parameters or key elements having greatest importance to a marine mammal relate to its ability to mature, reproduce, and survive.

The importance of the disruption and degree of consequence for individual marine mammals is often dependent on the frequency, intensity, and duration of the disturbance. Isolated acoustic disturbances such as underwater detonation usually have minimal consequences or no lasting effects for marine mammals. Marine mammals regularly cope with occasional disruption of their activities by predators, adverse weather, and other natural phenomena. It is reasonable to assume that they can tolerate occasional or brief disturbances by anthropogenic sound without significant consequences. However, prolonged disturbance, as might occur if a stationary and noisy activity were established near a concentrated area, is a more important concern. The long-term implications would depend on the degree of habituation within the population. If the marine mammals fail to habituate or become sensitized to disturbance and, as a consequence, are excluded from an important area or are subject to stress while at the important area, long-term effects could occur to individuals or the population.

In summary, the following points provide a context for evaluating the potential to impact individual marine mammals or marine mammal populations:

- Estimated mortality impacts are zero.
- All acoustic harassment effects are within the non-injurious TTS or behavioral effects zones (Level B harassment); the estimated number of animals potentially affected by Level A harassment (injury) is small.
- The take numbers presented in the preceding paragraphs are conservative (overestimates) because they do not take into account the mitigation measures described in Section 5. These measures are expected to substantially decrease the potential for explosive and acoustic impacts, especially within the mortality and injury zones. In addition, exposure calculations are based on the

assumption that all animals would occupy the same depth within the water column and do not take into account diving behavior, which could decrease exposure levels.

- The Navy reports that in at least three decades of training and testing activities in the Pacific ranges, only one instance of injury to marine mammals (up to four long-beaked common dolphins in 2011, in the Southern California range) has occurred as a result of impulsive sources (underwater explosion).

The Air Force concludes that detonation impacts from Long Range Strike WSEP missions proposed for 2017–2021 **may affect, and are likely to adversely affect**, individuals of ESA-listed marine mammal species. Impacts would be associated with sperm whale, false killer whale, and Hawaiian monk seal. However, based on the discussions above, the results of NMFS' evaluation of the proposed activities, and adherence to mitigation measures described in Section 5, the potential for impacts are expected to be reduced and no population-level effects to any marine mammal species or stock are anticipated.

4.2 Sea Turtles

4.2.1 Physical Strike

Similar to the discussion of marine mammals, sea turtles could be struck by weapons during Long Range Strike WSEP missions. While impact from an item as it falls through the water column is possible, it is not likely, because objects generally sink through the water slowly and can be avoided by most sea turtles. Therefore, strikes are only considered reasonably likely for turtles located at or within a few meters of the surface. In order to be struck, a turtle would have to be in the impact area at the point of impact, near the surface at the same time the weapon arrives. Only nine weapons (one JASSM and eight SDBs) will be released during the first year of testing. Over the following five years, up to 550 bombs and missiles will be deployed, for a maximum of 110 per year. Due to the number of weapons used and the generally scattered turtle distribution, it is unlikely that a sea turtle would be at the water surface at the same time and location where weapons would impact the water. In addition, turtles are submerged approximately 90 percent of the time, so time spent at the surface is limited. Required mitigation measures would further decrease the probability of a weapon strike.

The Air Force considers the potential for direct physical strikes resulting from Long Range Strike WSEP missions **may affect, but is not likely to adversely affect** ESA-listed sea turtles.

4.2.2 Ingestion Stressors

As described in the preceding marine mammal section, military expended materials potentially generated during Long Range Strike WSEP missions would include inert munitions and fragments of exploded bombs and missiles. Intact munitions would be too large to ingest, while munition fragments could be ingested. Sea turtle ingestion of plastics and other discarded items is well documented and may cause injury or death. The variety of debris items found in turtles suggests that feeding is at least somewhat nondiscriminatory and that they are prone to ingesting nonprey items. The impacts of ingested debris may be direct or indirect. For example, items may become lodged in the digestive tract and affect turtles by decreasing the ability to feed and absorb nutrients.

The potential for ingestion of military expended materials is a function of the quantity of items generated, location of the items, and sea turtle feeding methods. Floating materials or materials suspended in the water column could be eaten by turtles that feed at or near the surface, such as the leatherback, while items such as munitions fragments on the seafloor could be ingested by other species. A small number of floating items small enough to be ingested by a turtle, such as small munition fragments, could remain on the water surface for some time. If ingested, effects to an individual turtle would depend on the size and shape of the item relative to the size of the animal. Items could either pass through the digestive tract without incident, cause temporary disruption of feeding and digestion processes, or become permanently encapsulated by the stomach lining. The probability of a turtle encountering and eating floating military expended materials would be decreased by the small number of items produced during missions, dispersion by currents and wind, and the patchy distribution of turtles in the Pacific Ocean.

Most military expended materials would sink to the seafloor, and small items could be ingested by bottom-feeding turtles, including the loggerhead, olive ridley, hawksbill, and green turtle. Potential effects to an animal's health would be the same as those described for floating items above. The likelihood of ingestion is decreased by the water depth at which items would be deposited (bottom-feeding species are not known to routinely feed in water depths of over 4,000 meters). In addition, the potential for such encounters is low based on the relatively low number and patchy distribution of the items produced, and the patchy distribution of sea turtle feeding habitat. Further, an animal would not likely ingest every military expended material it encounters. Animals may attempt to ingest an item and then reject it after realizing it is not a food item. Ingestion of an item would not necessarily result in injury to mortality to the individual if the item does not become embedded in tissue. Therefore, impacts resulting from ingestion of military expended materials would be limited to the unlikely event where a sea turtle suffers a negative response from ingesting an item that becomes embedded in tissue or is too large to pass through the digestive system. Over time, many military expended materials would eventually become covered by sediment or colonized by attaching and encrusting organisms, which could reduce the potential for ingestion. Overall, it is not expected that large numbers of items on the seafloor would be consumed and result in harm to sea turtles.

In summary, it is possible that some military expended materials could be ingested by sea turtles and cause behavioral impacts, injury, decreased feeding ability, or death. Based on the discussion above, the Air Force considers that a small number of impacts could occur, and population-level effects on any species are considered unlikely. Therefore, ingestion of military expended materials resulting from Long Range Strike WSEP missions **may affect, but is not likely to adversely affect**, ESA-listed sea turtles.

4.2.3 Detonation Effects

Sea turtles spend most of their lives at sea, coming ashore only to nest and, in rare circumstances and locations, to bask. When at the water surface, sea turtles are mostly submerged. This makes turtles difficult to locate visually and also exposes them to effects of underwater explosions. Similar to other marine species, the susceptibility of sea turtles to mortality, injury, or harassment resulting from underwater detonations is influenced by factors such as animal size, animal and detonation depth, and distance between the animal and detonation. Near the detonation point, animals may be affected primarily by the shock wave, with typical effects including compression of gas-containing structures (e.g., lungs, GI tract), large pressure changes across tissue interfaces, and concussive effects (e.g., bone fractures). Pressure may also result in effects to the auditory system such as ear drum rupture.

The greatest potential for direct, non-auditory tissue impacts to sea turtles is primary blast injury and barotrauma after exposure to the shock waves of high-amplitude impulsive sources, such as explosions. Primary blast injuries result from the initial compression of a body exposed to the high pressure of a blast or shock wave. As described in Department of the Navy (2015), primary blast injury is usually limited to gas-containing structures (e.g., lung and gut) and the pressure-sensitive components of the auditory system, although additional injuries could include concussive brain damage and cranial, skeletal, or shell fractures. Barotrauma refers to injuries caused when large pressure changes occur across tissue interfaces, normally at the boundaries of air-filled tissues such as the lungs. Primary blast injury to the respiratory system may be fatal depending on the severity of the trauma. Rupture of the lung may introduce air into the vascular system, producing air blockages that can restrict oxygen delivery to the brain and heart. Although often secondary in life-threatening severity to pulmonary blast trauma, the gastrointestinal tract can also suffer bruising and tearing from blast exposure, particularly in air-containing regions of the tract. Potential traumas include internal bleeding, bowel perforation, tissue tears, and ruptures of the hollow abdominal organs. Although hemorrhage of solid organs (e.g., liver, spleen, and kidney) from blast exposure is possible, rupture of these organs is rarely encountered. Non-lethal injuries could increase a sea turtle's risk of predation, disease, or infection.

Sound produced by an underwater explosion may cause other hearing effects including hearing threshold shifts. A threshold shift occurs when intense sound causes fatigue or damage to the auditory system, resulting in a shift in the sound level that can be heard at a given frequency. That is, at the affected frequency, sound must be louder to be heard compared to the hearing ability before the shift. Such a shift may be temporary or permanent. At greater distances from the detonation, noise may cause stress or disruption of natural behaviors. Startle reactions may include increased surfacing, rapid swimming, or diving. Noise due to mission activities may affect habitat quality such that important biological behaviors may be disrupted (e.g., feeding, mating, and resting), and turtles may avoid the area because of the noise. The magnitude of those effects may be affected by the frequency, periodicity, duration, and intensity of the sounds, as well as the behavior of the animals during the exposure.

Compared to other species such as marine mammals, little is known about the role of sound and hearing in sea turtle survival, or the effects of human-caused noise. However, the results of various investigations indicate that sea turtles are most sensitive to low frequency sounds. Best sensitivities were found from 200 to 700 hertz (Hz) for the green turtle (Ridgway et al., 1969) and around 250 Hz or below for juvenile loggerheads (Bartol, 1999). The effective hearing range for marine turtles is generally considered to be between 30 and 2,000 Hz, with a range of maximum sensitivity between 100 and 800 Hz (Bartol, 1999; Ridgway, 1969; Lenhardt, 1994; Bartol and Ketten, 2006; Lenhardt, 2002). Hearing below 80 Hz is less sensitive but still potentially usable (Lenhardt, 1994). Additionally, calculated in-water hearing thresholds at best frequencies (100 to 1,000 Hz) appear to be high, at 160 to 200 dB re 1 μPa (Lenhardt, 1994). A study on the effects of airguns on sea turtle behavior also suggests that they are most likely to respond to low-frequency sounds (McCauley et al., 2000). Green and loggerhead turtles noticeably increased their swimming speed, as well as swimming direction, when received levels reached 166 dB re 1 μPa, and their behavior became increasingly erratic at 175 dB re 1 μPa (McCauley et al., 2000). There is no information regarding the long-term consequences of these disturbances, but short-term disruption in normal behaviors and temporary abandonment of habitat is likely in response to some noises produced by munitions testing.

Similar to the assessment of detonation effects on marine mammals, three sources of information are necessary for estimating potential pressure and acoustic effects on sea turtles: (1) the zone of influence, which is the distance from the explosion to which particular levels of impact would extend; (2) the density of animals within the zone of influence; and (3) the number of detonations (events). These components are discussed in further detail below. Appendix A contains a description of the acoustic modeling methodology used to determine the number of sea turtles potentially impacted by air-to-surface activities. Noise and pressure effects are evaluated only for detonations occurring at and beneath the water surface. In-air detonations are not included in impacts analysis because of the negligible transmission of energy and pressure across the air/water interface.

Zone of Influence

The zone of influence is defined as the area or volume of ocean in which sea turtles could be exposed to various pressure or acoustic energy levels caused by exploding ordnance. Refer to Appendix A for a description of the method used to calculate impact volumes for explosives.

Criteria and Thresholds

Until recently, there were no acoustic energy or pressure impact thresholds defined specifically for sea turtles, and in the absence of such information, the thresholds used for marine mammal analysis were typically applied. However, NMFS has recently endorsed sea turtle criteria and thresholds for impulsive sources (including detonations) to be used in impact analysis and were obtained from Finneran and

Jenkins (2012). In some cases, turtle-specific data are not available and marine mammal criteria are therefore used. Similar to marine mammal analysis, criteria and thresholds are provided for mortality (extensive lung injury), non-lethal injury (slight lung or GI tract injury), onset of PTS and TTS, and behavioral effects. Each of these metrics is described below and additional information is provided in Appendix A.

Onset of Mortality and Slight Lung Injury

The most commonly reported internal bodily injury to sea turtles resulting from explosive detonations is hemorrhaging in the fine structure of the lungs. The likelihood of internal bodily injury is related to the received impulse of the underwater blast (pressure integrated over time), not peak pressure or energy (Richmond et al., 1973; Yelverton and Richmond, 1981; Yelverton et al., 1973; Yelverton et al., 1975). Therefore, impulse is used as a metric upon which internal organ injury can be predicted. Onset mortality and onset slight lung injury are defined as the impulse level that would result in 1 percent mortality (most survivors have moderate blast injuries and should survive) and zero percent mortality (recoverable, slight blast injuries) in the exposed population, respectively. Criteria for onset mortality and onset slight lung injury were developed using data from explosive impacts on mammals (Yelverton and Richmond, 1981).

The impulse required to cause lung damage is related to the volume of the lungs, which in turn is related to the size (mass) of the animal and compression of gas-filled spaces at increasing water depth. Turtles have relatively low lung volume to body mass and a relatively stronger anatomical structure compared to mammals. Therefore, application of the criteria derived from studies of impacts on mammals is likely conservative.

Table 4-6 provides an estimated conservative body mass for each sea turtle species, based on juvenile mass. Juvenile body mass is used due to the early rapid growth (newborn turtles weigh less than 0.5 percent of maximum adult body mass). Scaling of lung volume to depth is conducted for all species because data come from experiments with terrestrial animals held near the water's surface. The calculation of impulse thresholds consider depth of the animal to account for compression of gas-filled spaces that are most sensitive to impulse injury. The impulse required for a specific level of injury is assumed to increase with depth (Goertner, 1982). Additionally, to reach the threshold for onset slight lung injury or onset mortality, the critical impulse value must be delivered during a period that is the lesser of the initial positive pressure duration or 20 percent of the natural period of the assumed-spherical lung adjusted for size and depth of the animal. Therefore, as depth increases or animal size decreases, impulse delivery time decreases (Goertner, 1982).

Table 4-6. Sea Turtle Masses Used to Determine Onset of Mortality and Slight Lung Injury

Species	Juvenile Mass	Information Source
Loggerhead sea turtle	8.4 kg	Southwood et al., 1999
Green sea turtle	8.7 kg	Wood and Wood, 1993
Hawksbill sea turtle	7.4 kg	Okuyama et al., 2010
Olive ridley sea turtle[1]	6.3 kg	McVey and Wibbles, 1994; Caillouet et al., 1995
Leatherback sea turtle	34.8 kg	Jones, 2009

[1]Mass based on the Kemp's ridley turtle

Onset of Gastrointestinal Tract Injury

In the absence of turtle-specific information, data from tests with terrestrial animals are used to predict onset of GI tract injury. Gas-containing internal organs, such as the lungs and intestines, were the principle damage sites from shock waves in submerged terrestrial mammals (Clark and Ward, 1943; Greaves et al., 1943; Richmond et al., 1973; Yelverton et al., 1973). In addition, slight injury to the GI tract may be related to the magnitude of the peak shock wave pressure over the hydrostatic pressure, and would be independent of the animal's size and mass (Goertner, 1982). Slight contusions to the GI tract were reported during small charge tests (Richmond et al., 1973), when the peak was 237 dB re 1 µPa. Therefore, this value is used to predict onset of GI tract injury in sea turtles exposed to explosions.

Temporary and Permanent Hearing Threshold Shift

Animals generally do not hear equally well across their entire hearing range. Numerous studies indicate that sea turtles are most sensitive to low-frequency sounds, although sensitivity may vary slightly by species and age class (Bartol and Ketten, 2006; Bartol et al., 1999 Lenhardt, 1994; Ridgway et al., 1969). Because hearing thresholds are frequency-dependent, an auditory weighting function was developed for sea turtles (turtle-weighting, or T-weighting). The T-weighting function simply defines lower and upper frequency boundaries beyond which sea turtle hearing sensitivity decreases. The single frequency cutoffs at each end of the frequency range where hearing sensitivity begins to decrease are based on the most liberal interpretations of sea turtle hearing abilities (10 Hz and 2 kHz). These boundaries are precautionary and exceed the demonstrated or anatomy-based hypothetical upper and lower limits of sea turtle hearing. The T-weighting function adjusts the received sound level, emphasizing frequencies to which sea turtles are most sensitive and reducing emphasis on frequencies outside of their estimated useful range of hearing.

To date, no known data are available on potential hearing impairments (TTS and PTS) in sea turtles. Based on best available science regarding TTS generally in marine vertebrates (Finneran et al., 2005; Finneran et al., 2000; Finneran et al., 2002; Nachtigall et al., 2003; Nachtigall et al., 2004; Schlundt et al., 2000), the respective total T-weighted sound exposure level of 172 dB re 1 μPa^2-s or peak pressure of 224 dB re 1 µPa (23 pounds per square inch [psi]) is used to estimate exposures resulting in TTS for sea turtles. Onset of PTS levels for these animals is estimated by adding 15 dB to the sound exposure level-based TTS threshold and adding 6 dB to the peak pressure-based thresholds. These relationships were derived by Southall et al. (2007) from impulsive noise TTS growth rates in chinchillas. This results in onset of PTS thresholds of total weighted sound exposure level of 187 dB re 1 μPa^2-s or peak pressure of 230 dB re 1 µPa for sea turtles.

Behavioral Response

A sea turtle's behavioral responses to sound are assumed to be variable and context specific. Most responses would likely be short-term avoidance reactions. A few studies investigated behavioral responses of sea turtles to impulsive sounds emitted by airguns (McCauley et al., 2000; Moein Bartol et al., 1995; O'Hara and Wilcox, 1990). Overall, airgun studies indicate that perception and a behavioral reaction to a repeated sound may occur with sound pressure levels greater than 166 dB re 1 µPa root mean square, and that more erratic behavior and avoidance may occur at higher thresholds around 175 to 179 dB re 1 µPa root mean square (McCauley et al., 2000; Moein Bartol et al., 1995; O'Hara and Wilcox, 1990). A received level of 175 dB re 1 µPa root mean square is more likely to be the point at which avoidance may occur (McCauley et al., 2000). Currently, an unweighted level (not peak level) of 175 dB re 1 µPa root mean square is considered to be the applicable behavioral threshold level.

4.2.4 Sea Turtle Density

Similar to the discussion of marine mammals, the number of sea turtles potentially affected by detonations may be considered in terms of density, which is the number of animals present in the affected area. A significant amount of effort is required to collect and analyze survey data sufficient for producing useable marine species density estimates, and as a result there is often no single source of density available for every area, species, and season of interest. The sea turtle density estimate used in this document is taken from the U.S. Navy's Pacific Marine Species Density Database (U.S. Department of the Navy, 2014), which includes a compilation of the best available density data.

As discussed in U.S. Department of the Navy (2014), in-water occurrence data for sea turtles are severely limited. Although tagging studies have been conducted, there is typically little information on occurrence beyond beach areas. Many studies assess turtle abundance by counting nesting individuals or number of eggs, or by recording bycatch. Generally, in-water densities cannot be adequately estimated from such information. Accordingly, density estimates for the HRC are derived entirely from Navy data obtained through dive surveys and projects associated with Integrated Natural Resource Management Plans. Due to the relative scarcity of some species and the lack of density estimates for sea turtles associated with open ocean habitats such as the BSURE area, all sea turtle species are combined into a single guild, termed "Pacific Sea Turtles," for purposes of impacts assessment. This group theoretically encompasses all five species with potential occurrence in the Study Area, although only green and hawksbill sea turtles are known to have been observed in the HRC by Navy divers and contractors. Loggerhead, leatherback, and olive ridley turtles could conceivably pass through the area during migration, but the Navy considers the likelihood of occurrence to be extremely low. Nevertheless, these species are included in the guild and assumed to have some potential for occurrence.

Turtles have primarily been observed by Navy divers and contractors within the 100-meter isobath (and usually much shallower than 100 meters) around the Islands of Kauai, Lanai, Molokai, and Oahu, and density values have been directly calculated only within this depth contour. Densities beyond this depth in the open ocean are expected to be substantially less. For areas of the HRC outside the 100-meter isobath, the Navy used the mean density around the islands reduced by two orders of magnitude. The Navy applied a density correction factor to account for diving turtles and turtles that were at the surface but not seen by observers. Specifically, it was estimated that only 10 percent of the turtles actually present were seen.

The resulting density estimate used for impacts analysis in this document is shown in Table 4-7. This density value corresponds to all life stages of the Pacific Sea Turtles group occurring in the open ocean (beyond the 100-meter isobath) in all seasons. The density is considered the best available in the Study Area.

Table 4-7. Sea Turtle Density Estimate

Species	Location	Density (animals per km^2)
Pacific Sea Turtles (combined group of green, hawksbill, olive ridley, loggerhead, and leatherback sea turtles)	Outside of 100-meter isobath	0.00429

Density is typically reported for an area (e.g., animals per square kilometer). Density estimates usually assume that animals are uniformly distributed within the affected area, even though this is rarely true. Marine species may be clumped in areas of greater importance; for example, animals may be more concentrated in areas offering greater food availability, lower predation, etc. However, because there are usually insufficient data to calculate density for small areas, an even distribution is typically assumed for impact analyses.

Although the Study Area is depicted as only the surface of the water, in reality, density implicitly includes animals anywhere within the water column under that surface area. Assuming that sea turtles are distributed evenly within the water column does not accurately reflect animal behaviors. Individuals may be at or near the surface, or engaged in diving at any given time. Some species conduct deeper dives than others. Assuming that all individuals are evenly distributed from surface to bottom is almost never appropriate and can present a distorted view of turtle distribution in any region. The depth distribution for each species included in the Study Area is provided in Appendix B. Combining sea turtle density with depth information would result in three-dimensional density estimates and more accurate modeling of potential exposures from specific noise sources. However, as discussed in Section 4.1 (Marine Mammals), current guidance is to assume a two-dimensional density value to calculate exposure estimates as the product of affected area, density, and number of events. The resulting exposure estimates are considered conservative because all animals are presumed to be located at the same depth corresponding to the maximum sound and pressure ranges from detonations. In reality, most sea turtles present near the impact area at the time of a detonation would be at various depths in the water column and not necessarily occur at the same depth corresponding to the maximum sound and pressure ranges.

4.2.5 Number of Events

As discussed in the marine mammal impacts analysis, an "event" refers to a single, unique action that has the potential to expose sea turtles to various pressure and/or sound levels. The number of events generally corresponds to the number of live ordnance items released within a 24-hour period. For 2016 missions, all live ordnance is proposed to be released on the same mission day, which would equate to a single event with multiple releases. As described in the marine mammals section, up to four SDBs may be released simultaneously and detonate as a burst. One single JASSM/JASSM-ER release and two SDB bursts are proposed for 2016. The total energy for all releases is summed for impact calculations, but the pressure component is not. For 2017–2021, the exact number and type of munitions that would be released each day is not known and would vary. To account for total annual impacts, the total number of each munition proposed to be released per year was divided by five (annual number of mission days), which was treated as a representative mission day. As with the 2016 mission, the total energy for all weapon releases in a representative mission day is summed for impact calculations. Unlike 2016 missions, five mission days per year are planned during the time frame of 2017–2021. Refer to Appendix A for a detailed explanation of modeling methods.

4.2.6 Exposure Estimates

Based on the acoustic modeling described in Appendix A, Table 4-8 provides the maximum estimated range, or radius, from the detonation point to which the various thresholds extend (summer season). These ranges are used to calculate the total area (circle) of the zones of influence for each criterion/threshold. To eliminate "double-counting" of animals, impact areas from higher impact categories (e.g., mortality) were subtracted from areas associated with lower impact categories (e.g., Level A harassment). The adjusted impact areas were then combined with sea turtle density values and the number of events to provide an estimate of the number of sea turtles potentially exposed to the various impact thresholds. For metrics with two criteria (e.g., 187 dB SEL and 230 dB SPL for PTS), the criterion that results in the higher exposure estimate is used for impact calculations. Exposure estimates do not take into account required mitigation and monitoring measures, which are described in Section 5.

Missions Conducted in 2016

Similar to the discussion in the marine mammal section, potential impacts resulting from detonations are presented separately for the first year of testing (2016) and for the following five years. Immediate evaluations for JASSM/JASSM-ER and SDB I are needed for a smaller number of munitions in 2016 as compared to 2017–2021. Weapon release parameters would involve the release of one live JASSM/JASSM-ER and up to eight live SDB-I/II munitions in bursts of four. The resulting total number of sea turtles potentially affected is shown in Table 4-9. For some thresholds, exposure calculations from the model output resulted in decimal values, suggesting that a fraction of an animal was exposed. In these cases, the model results were rounded to the nearest whole number.

The table indicates the potential for a total of one TTS exposure for sea turtles. It is likely that this exposure would be associated with either a green or hawksbill sea turtle. There would be no impacts to sea turtles associated with mortality, injury, permanent hearing effects, or behavioral effects. Exposure calculations do not take into account the mitigation measures described in Section 5.

Due to the one calculated TTS exposure, the Air Force considers that detonation effects from Long Range Strike WSEP missions proposed for 2016 **may affect, and are likely to adversely affect** ESA-listed sea turtles.

Table 4-8. Threshold Radii (in meters) for Long Range WSEP Missions

Pacific Sea Turtles	Onset Mortality	Onset Slight Lung Injury	Onset Slight GI Tract Injury	Onset PTS		Onset TTS		Behavioral
	Criteria based on Yelverton and Richmond (1981)		237 dB SPL	187 dB SEL (T^2)	230 dB SPL	172 dB SEL (T^2)	224 dB SPL	175 dB RMS (unweighted)
2016 Mission	153	285	165	2,328	329	6,558	597	6,129
2017–2021 Typical Mission Day	340	631	204	4,336	413	15,340	763	12,010

dB = decibel; GI = gastrointestinal; PTS = permanent threshold shift; RMS = root mean square; SEL = sound exposure level; SPL = sound pressure level; TTS = temporary threshold shift

Table 4-9. Number of Sea Turtles Potentially Affected by Long Range Strike WSEP Missions (2016)

Species	Mortality	Slight Lung Injury	Slight GI Tract Injury	PTS	TTS	Behavioral
Pacific Sea Turtles	0	0	0	0	1	0

GI – gastrointestinal; PTS = permanent threshold shift; TTS = temporary threshold shift

Missions Conducted from 2017 to 2021

As previously stated, proposed munition releases for 2017–2021 missions are greater than what is proposed for 2016 missions. For missions conducted from 2017 to 2021, Table 4-10 indicates the resulting total number of sea turtles potentially affected under the various metrics in the absence of mitigation measures. The numbers represent total yearly impacts for all detonations combined. Similar to the modeling results for 2016, the exposure calculations resulted in decimal values, suggesting that a fraction of an animal was exposed. To eliminate this, the model results were rounded to the nearest whole number. In addition, to eliminate "double counting" of animals, exposure results from higher impact categories (e.g., mortality) were subtracted from lower impact categories (e.g., Level A harassment). For impact categories with multiple criteria and/or thresholds, numbers in the table are based on the threshold resulting in the greatest number of exposures.

Table 4-10. Number of Sea Turtles Potentially Affected by Long Range Strike WSEP Missions (2017–2021)

Species	Mortality	Slight Lung Injury	Slight GI Tract Injury	PTS	TTS	Behavioral
Pacific Sea Turtles[1]	0	0	0	1	15	0

GI = gastrointestinal; PTS = permanent threshold shift; TTS = temporary threshold shift
[1]Number of animals impacted by higher thresholds subtracted from less impactive thresholds

The table indicates the potential for PTS and TTS in the absence of mitigation measures. The mitigation and monitoring requirements described in Section 5 may afford some protection for sea turtles.

Available literature suggests that sea turtles are most likely to respond to low frequency sounds. Observations of turtles in the vicinity of airgun operations, which produce broadband noise including low frequency signals (similar to underwater explosions), indicate that individuals increase swimming activity at received levels between 166 and 175 dB re 1 µPa and exhibit more pronounced behavior changes such as erratic movements and increased diving at higher received levels (McCauley et al., 2000; DeRuiter and Larbi Doukara, 2012). Although it is possible that sea turtles in the vicinity of an in-water detonation might experience a temporary or permanent hearing threshold shift, it is not known what energy levels and received levels are necessary to induce threshold shifts (TTS and PTS thresholds are estimated based on general marine vertebrate hearing effects). Overall, the Air Force considers that Long Range Strike WSEP missions are not likely to interact with a sufficient number of sea turtles to reduce the reproduction, population numbers, or distribution of any species.

The Air Force concludes that detonations effects associated with Long Range Strike WSEP missions from 2017 to 2021 **may affect, and are likely to adversely affect**, individuals of ESA-listed sea turtle species. Impacts are most likely to be associated with green and hawksbill sea turtles, as these are the only species commonly reported in offshore portions of the BSURE area. There is a small potential for affected species to include loggerhead, olive ridley, or leatherback sea turtles. Based on the discussions above, the results of NMFS' evaluation of the proposed activities, and adherence to mitigation measures discussed in Section 5, the potential for impacts are expected to be reduced and there would be no population-level effects to any sea turtle species.

This page is intentionally blank.

5.0 Mitigations

Mitigations are measures taken to lessen or eliminate the impacts of an action. As defined in CEQ Regulations (40 CFR §1508.20), mitigation includes the following:

- Avoiding the impact altogether by not taking a certain action or part of an action
- Minimizing impacts by limiting the degree of magnitude of the action and its implementation
- Rectifying the impact by repairing, rehabilitating, or restoring the affected environment
- Reducing or eliminating the impact over time through preservation and maintenance operations during the life of the action
- Compensating for the impact by replacing or providing substitute resources or environments

The potential marine mammal and sea turtle takes discussed in the preceding sections represent the maximum expected number of animals that could be exposed to particular noise and pressure thresholds. The impact estimates do not take into account measures that will be employed to minimize impacts to marine species. Unlike standard operating procedures, which are established for reasons other than environmental benefit, mitigation measures are modifications to the proposed activities that are implemented for the sole purpose of reducing a specific potential environmental impact on a particular resource. The procedures discussed in this section are, in general, routinely implemented for test events in the PMRF as a result of previous U.S. Navy environmental compliance documents, ESA biological opinions, MMPA incidental harassment authorizations or letters of authorization, or other formal or informal consultations with regulatory agencies. The Air Force has worked with PMRF personnel to ensure mitigation measures are adequate and meet NMFS' expectations based on requirements identified for past similar actions conducted in the PMRF and BSURE areas. The overall approach to assessing potential mitigation measures in the BSURE area is based on two principles: (1) mitigations will be effective at reducing potential impacts on the resource, and (2) mitigation is consistent with mission objectives, range procedures, and safety measures.

For missions involving air-to-surface weapon employment in the BSURE area, such as long range WSEP activities, mitigation procedures consist of visual aerial surveys of the impact area for the presence of protected species (marine mammals and sea turtles). During aerial observation, Navy test range personnel may survey the area from a S-61N helicopter or C-62 aircraft that is based at the PMRF land facility (typically when missions are located relatively close to shore). Alternatively, when missions are located farther offshore, surveys may be conducted from mission aircraft (typically jet aircraft such as F-15E, F-16, or F-22) or a U.S. Coast Guard C-130 aircraft.

Protected species surveys typically begin within one hour of weapon release and as close to the impact time as feasible, given human safety requirements. Survey personnel must depart the human hazard zone before weapon release, in accordance with Navy safety standards. Personnel conduct aerial surveys within an area defined by an approximately 2-NM (3,704 m) radius around the impact point, with surveys typically flown in a star pattern. This survey distance is consistent with requirements already in place for similar actions at PMRF and, for 2016 missions, encompasses all PTS (SEL and SPL) impact areas and TTS (SPL) impact areas for ESA-listed marine mammals and sea turtles. However, the survey distance covers over 50 percent of the TTS (SEL) impact area for sea turtles (see Table 4-8 and Table 4-9). For 2017–2021 missions, the survey distance would also cover all PTS (SEL and SPL) impact areas and TTS (SPL) impact areas for ESA-listed marine mammals and sea turtles. The survey area would not encompass TTS SEL or behavioral harassment impact areas. For sea turtles, the survey area would cover about 85 percent of the PTS threshold impact area. Given operational constraints, surveying larger areas would not be feasible.

Observers would consist of aircrew operating the C-26, S-61N, and C-130 aircraft from PMRF and the Coast Guard. These aircrew are trained and experienced at conducting aerial marine mammal surveys and have provided similar support for other missions at PMRF. Aerial surveys are typically conducted at an altitude of about 200 feet, but altitude may vary somewhat depending on sea state and atmospheric conditions. If adverse weather conditions preclude the ability for aircraft to safely operate, missions would either be delayed until the weather clears or cancelled for the day. For 2016 Long Range Strike WSEP missions, one day has been designated as a weather back-up day. The C-26 and other aircraft would generally be operated at a slightly higher altitude than the helicopter. The observers will be provided with the GPS location of the impact area. Once the aircraft reaches the impact area, pre-mission surveys typically last 30 minutes, depending on the survey pattern. The fixed-wing aircraft are faster than the helicopter, and, therefore, protected species may be more difficult to spot. However, to compensate for the difference in speed, the aircraft may fly the survey pattern multiple times.

If a protected species is observed in the impact area, weapon release would be delayed until one of the following conditions is met: (1) the animal is observed exiting the impact area, (2) the animal is thought to have exited the impact area based on its course and speed, or (3) the impact area has been clear of any additional sightings for a period of 30 minutes. All weapons will be tracked and their water entry points will be documented. Post-mission surveys would begin immediately after the mission is complete and the Range Safety Officer declares the human safety area is reopened. Approximate transit time from the perimeter of the human safety area to the weapon impact area would depend on the size of the human safety area and would vary between aircraft, but is expected to be less than 30 minutes. Post-mission surveys would be conducted by the same aircraft and aircrew that conducted the pre-mission surveys and would follow the same patterns as pre-mission surveys, but would focus on the area down current of the weapon impact area to determine if protected species were affected by the mission (observation of dead or injured animals). During post-mission surveys, if an animal is found to have been injured or otherwise adversely impacted, NMFS will be notified. If an injury or mortality occurs to a protected species due to Long Range Strike WSEP missions, all records would be sealed and held for investigation. Additional consultation with NMFS may be required prior to conducting the next mission.

For marine mammals specifically, NMFS has specified the following reporting and activity requirements:

- In the unanticipated event that Long Range Strike WSEP activities clearly cause the take of a marine mammal in a manner not authorized by NMFS, the 86 FWS will immediately cease activities and report the incident to the NMFS Office of Protected Resources and the Regional Stranding Coordinator. Activities will not resume until NMFS reviews the circumstances of the take and determines what further measures are necessary to minimize the likelihood of further prohibited take.
- If an injured or dead marine mammal is discovered, and the cause of injury or death is unknown and the injury or death occurred relatively recently, the 86 FWS will immediately report the incident to the NMFS Office of Protected Resources and the Regional Stranding Coordinator. Activities may continue while NMFS reviews the incident.
- If an injured or dead marine mammal is discovered, and the observer determines that the injury or death is not related to Long Range Strike WSEP activities, the 86 FWS will report the incident to the NMFS Office of Protected Resources and the Regional Stranding Coordinator within 24 hours, and may provide photographs, video footage, or other documentation of the affected animal.

6.0 Summary of Conclusions

Based on the analyses in Section 4, ESA-listed marine mammals are **not likely to be adversely affected** by Long Range Strike WSEP missions in 2016 and are **likely to be adversely affected** due to surface and underwater detonations during Long Range Strike WSEP missions in the BSURE area from 2017 to 2021. Furthermore, ESA-listed sea turtles are **likely to be adversely affected** by Long Range Strike WSEP missions in 2016, as well as missions proposed from 2017 to 2021. Adherence to mitigation measures, as described in Section 5, will likely help to reduce the potential for adverse impacts to mammals, and may help to reduce the potential for adverse impacts to sea turtles.

This page is intentionally blank.

7.0 List of Preparers

Amanda Robydek, Environmental Scientist
Leidos
Eglin AFB Natural Resources
107 Highway 85 North
Niceville, FL 32578
(850) 882-8395
amanda.robydek.ctr@eglin.af.mil

Rick Combs, Environmental Scientist
Leidos
1140 Eglin Parkway
Shalimar, FL 32579
(850) 609-3459
ronald.r.combs@leidos.com

Brian Sperry, Ph.D., Senior Scientist
Leidos
4001 N. Fairfax Dr., Suite 600
Arlington, VA 22203
(703) 907-2551
brian.j.sperry@leidos.com

This page is intentionally blank.

8.0 Review of Literature and Other Pertinent Information

Acevedo-Gutiérrez, A., D. A. Croll, and B. R. Tershy (2002). "High feeding costs limit dive time in the largest whales." Journal of Experimental Biology 205: 1747-1753.

Afsal, V. V., P. P. Manojkumar, K. S. S. M. Yousuf, B. Anoop, and E. Vivekanandan (2009). "The first sighting of Longman's beaked whale, *Indopacetus pacificus* in the southern Bay of Bengal." Marine Biodiversity Records 2: 1-3.

Aguayo, L. A., and T. R. Sanchez (1987). "Sighting records of Fraser's dolphin in the Mexican Pacific waters." Scientific Reports of the Whales Research Institute 38: 187-188.

Aguilar, A. (2008). Fin whale *Balaenoptera physalus*. In: Encyclopedia of Marine Mammals. W. F. Perrin, B. Wursig and J. G. M. Thewissen. Amsterdam, Academic Press**:** 433-437.

Aguilar Soto, N., M. P. Johnson, P. T. Madsen, F. Diaz, I. Dominguez, A. Brito, and P. Tyack (2008). "Cheetahs of the deep sea: Deep foraging sprints in short-finned pilot whales off Tenerife (Canary Islands)." Journal of Animal Ecology 77(5): 936-947.

Aissi, M., A. Celona, G. Comparetto, R. Mangano, M. Wurtz, and A. Moulins (2008). "Large-scale seasonal distribution of fin whales (Balaenoptera physalus) in the central Mediterranean Sea." Journal of the Marine Biological Association of the United Kingdom 88: 1253-1261.

Aki, K., R. Brock, J. Miller, J. R. Mobley Jr., P. J. Rappa, D. Tarnas, and M. Yuen (1994). A Site Characterization Study for the Hawaiian Islands Humpback Whale National Marine Sanctuary. (pp. 119). Prepared by University of Hawaii Sea Grant College Program School of Ocean and Earth Science and Technology. Prepared for National Oceanic and Atmospheric Administration.

Allen, B. M., and R. P. Angliss (2015). Stock Assessment Report. Humpback whale (*Megaptera novaengliea*): Central North Pacific Stock. NOAA Technical Memorandum NOAA-TM-AFSC-301. Revised 10/09/2014.

Allen, B. M., and R. P. Angliss (2014). *Alaska Marine Mammal Stock Assessments 2014*. Humpback whale (*Megaptera novaengliea*): Central North Pacific Stock. NOAA Technical Memorandum NOAA-TM-AFSC-301. Revised 10/09/2014.

Allen, B. M., and R. P. Angliss (2013). *Alaska Marine Mammal Stock Assessments 2012*. NOAA Technical Memorandum NMFS-AFSC-245, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center**:** 282.

Alonso, M. K., S. N. Pedraza, A. C. M. Schiavini, R. N. P. Goodall, and E. A. Crespo. (1999). "Stomach contents of false killer whales (*Pseudorca crassidens*) stranded on the coasts of the Strait of Magellan, Tierra del Fuego." Marine Mammal Science 15(3): 712-724.

Alves, F., A. Dinis, I. Cascao, and L. Freitas (2010). "Bryde's whale (*Balaenoptera brydei*) stable associations and dive profiles: New insights from foraging behavior." Marine Mammal Science 26(1): 202-212.

Anderson, R. C., R. Clark, P. T. Madsen, C. Johnson, J. Kiszka, and O. Breysse (2006). "Observations of Longman's beaked whale (*Indopacetus pacificus*) in the Western Indian Ocean." Aquatic Mammals 32(2): 223-231.

Antonelis, G. A., J. D. Baker, T. C. Johanos, R. C. Braun, and A. L. Harting (2006). "Hawaiian monk seal (*Monachus schauinslandi*): Status and conservation issues." Atoll Research Bulletin 543: 75-101.

Archer, F. I., and W. F. Perrin (1999). "Stenella coeruleoalba." Mammalian Species 603: 1-9.

Arenas, P., and M. Hall (1992). The association of sea turtles and other pelagic fauna with floating objects in the eastern tropical Pacific Ocean. In M. Salmon and J. Wyneken (Eds.), Proceedings of the Eleventh Annual Workshop on Sea Turtle Biology and Conservation. (NOAA Technical Memorandum NMFS-SEFSC-302, pp. 7-10) U.S. Department of Commerce, National Oceanic and Atmospheric Administration and National Marine Fisheries Service.

Au, D. W. K., and W. L. Perryman (1985). "Dolphin habitats in the eastern tropical Pacific." Fishery Bulletin 83: 623-643.

Ayres, K. l. R. K. Booth, J. A. Hempelmann, K. L. Koski, C. K. Emmons, R. W. Baird, K. Balcomb-Bartok, M. B. Hanson, M. J. Ford, and S. K. Wasser (2012). Distinguishing the Impacts of Inadequate Prey and Vessel Traffic on an Endangered Killer Whale (Orcinus orca) Population. PLoS ONE:7(6), pp 12.

Azzellino, A., S. Gaspari, S. Airoldi, and B. Nani (2008). "Habitat use and preferences of cetaceans along the continental slope and the adjacent pelagic waters in the western Ligurian Sea." Deep Sea Research I 55: 296–323.

Baird, R. W. (2009a). *A review of false killer whales in Hawaiian waters: Biology, status, and risk factors*. Olympia, WA, Cascadia Research Collective**:** 41.

Baird, R. W. (2009b). False killer whale *Pseudorca crassidens*. In: Encyclopedia of Marine Mammals (Second Edition). W. F. Perrin, B. Wursig and J. G. M. Thewissen, Academic Press**:** 405-406.

Baird, R. W. (2006). "Hawai'i's other cetaceans." Whale and Dolphin Magazine 11: 28-31.

Baird, R. W. (2005). "Sightings of dwarf (*Kogia sima*) and pygmy (*K. breviceps*) sperm whales from the main Hawaiian Islands." Pacific Science 59: 461-466.

Baird, R. W., S. W. Martin, D. L. Webster, and B. L. Southall (2014). *Assessment of Modeled Received Sound Pressure Levels and Movements of Satellite-Tagged Odontocetes Exposed to Mid-Frequency Active Sonar at the Pacific Missile Range Facility: February 2011 Through February 2013*. Prepared for U.S. Pacific Fleet, submitted to NAVFAC PAC by HDR Environmental, Operations and Construction, Inc.

Baird, R. W., D. L. Webster, J. M. Aschettino, G. S. Schorr, D. J. McSweeney (2013). Odontocete cetaceans around the main Hawaiian Islands: Habitat use and relative abundance from small-boat sighting surveys. Aquatic Mammals 39:253-269.

Baird, R.W., D. L. Webster, G. S. Schorr, J. M. Aschettino, A. M. Gorgone, and S. D. Mahaffy (2012). "Movements and Spatial Use of Odontocetes in the Western Main Hawaiian Islands: Results from Satellite-Tagging and Photo-Identification off Kauai and Niihau in July/August 2011". Technical Report: NPS-OC-12-003CR; http://hdl.handle.net/10945/13855.

Baird, R., G. Schorr, D. Webster, D. McSweeney, M. Hanson, and R. Andrews (2010a). Movements and habitat use of Cuvier's and Blainville's beaked whales in Hawaii: results from satellite tagging in 2009/2010. C. Research. La Jolla, CA.

Baird, R. W., G. S. Schorr, D. L. Webster, D. J. McSweeney, M. B. Hanson, and R. D. Andrews (2010b). "Movements and habitat use of satellite-tagged false killer whales around the main Hawaiian Islands." Endangered Species Research 10: 107-121.

Baird, R. W., A. M. Gorgone, D. J. McSweeney, A. D. Ligon, M. H. Deakos, D. L. Webster, G. S. Schorr, K. K. Martien, D. R. Salden, and S. D. Mahaffy (2009a). "Population structure of island-associated dolphins: Evidence from photo-identification of common bottlenose dolphins (*Tursiops truncatus*) in the main Hawaiian Islands." Marine Mammal Science 25(2): 251-274.

Baird, R. W., D. J. McSweeney, G. S. Schorr, S. D. Mahaffy, D. L. Webster, J. Barlow, M. B. Hanson, J. P. Turner, and R. D. Andrews (2009b). Studies of beaked whales in Hawai'i: Population size, movements, trophic ecology, social organization, and behaviour. In: Beaked Whale Research. S. J. Dolman, C. D. MacLeod and P. G. H. Evans, European Cetacean Society**:** 23-25.

Baird, R. W., D. L. Webster, S. D. Mahaffy, D. J. McSweeney, G. S. Schorr, and A. D. Ligon (2008a). "Site fidelity and association patterns in a deep-water dolphin: Rough-toothed dolphins (*Steno bredanensis*) in the Hawaiian Archipelago." Marine Mammal Science 24(3): 535-553.

Baird, R., D. McSweeney, C. Bane, J. Barlow, D. Salden, L. Antoine, R. LeDuc, and D. Webster (2006a). "Killer whales in Hawaiian waters: Information on population identity and feeding habits." Pacific Science 60(4): 523–530.

Baird, R. W., G. S. Schorr, D. L. Webster, D. J. McSweeney, and S. D. Mahaffy (2006b). Studies of beaked whale diving behavior and odontocete stock structure in Hawai'i in March/April 2006**:** 31.

Baird, R. W., A. M. Gorgone, D. L. Webster, D. J. McSweeney, J. W. Durban, A. D. Ligon, D. R. Salden, and M. H. Deakos (2005). False killer whales around the main Hawaiian Islands: An assessment of interisland movements and population size using individual photo-identification (*Pseudorca crassidens*). Report prepared under Order No. JJ133F04SE0120 from the Pacific Islands Fisheries Science Center, National Marine Fisheries Service, 2570 Dole Street, Honolulu, HI 96822. 24pgs. 2005.

Baird, R. W., D. L. Webster, D. J. McSweeney, A. D. Ligon, and G. S. Schorr (2005b). Diving behavior and ecology of Cuvier's (*Ziphius cavirostris*) and Blainville's beaked whales (*Mesoplodon densirostris*) in Hawai'i. La Jolla, CA.

Baird, R. W., M. B. Hanson, E. E. Ashe, M. R. Heithaus, and G. J. Marshall (2003a). *Studies of Foraging in "Southern Resident" Killer Whales during July 2002: Dive Depths, Bursts in Speed, and the Use of a "Crittercam" System for Examining Sub-surface Behavior*. Seattle, WA, U.S. Department of Commerce, National Marine Fisheries Service, National Marine Mammal Laboratory**:** 18.

Baird, R. W., D. J. McSweeney, D. L. Webster, A. M. Gorgone, and A. D. Ligon (2003b). Studies of odontocete population structure in Hawaiian waters: Results of a survey through the main Hawaiian Islands in May and June 2003. Seattle, WA, NOAA**:** 25.

Baird, R. W., A. D. Ligon, S. K. Hooker, and A. M. Gorgone (2001). Subsurface and nighttime behaviour of pantropical spotted dolphins in Hawai'i. *Canadian Journal of Zoology, 79*(6), 988-996.

Baird, R. W., S. W. Martin, D. L. Webster, and B. L. Southall (2014). *Assessment of Modeled Received Sound Pressure Levels and Movements of Satellite-Tagged Odontocetes Exposed to Mid-Frequency Active Sonar at the Pacific Missile Range Facility: February 2011 Through February 2013*. Prepared for U.S. Pacific Fleet, submitted to NAVFAC PAC by HDR Environmental, Operations and Construction, Inc.

Baker, J. D. (2008). "Variation in the relationship between offspring size and survival provides insight into causes of mortality in Hawaiian monk seals." Endangered Species Research 5: 55-64.

Baker, J. D. (2004). "Evaluation of closed capture-recapture methods to estimate abundance of Hawaiian monk seals." Ecological Applications 14: 987-998.

Baker, J. D., and T. C. Johanos (2004). "Abundance of the Hawaiian monk seal in the main Hawaiian Islands." Biological Conservation 116(1): 103-110.

Baker, A. N., and B. Madon (2007). "Bryde's whales (Balaenoptera cf. brydei Olsen 1913) in the Hauraki Gulf and northeastern New Zealand waters." Science for Conservation 272: 4-14.

Baker, J. D., A. L. Harting, and T. C. Johanos (2006). "Use of discovery curves to assess abundance of Hawaiian monk seals." Marine Mammal Science 22(4): 847-861.

Balazs, G. H. (1995). Status of sea turtles in the central Pacific Ocean. In K. A. Bjorndal (Ed.), Biology and Conservation of Sea Turtles (Revised ed., pp. 243-252). Washington, DC: Smithsonian Institution Press.

Balazs, G. H. (1980). Synopsis of Biological Data on the Green sea turtle in the Hawaiian Islands. (NOAATM-NMFS-SWFC-7, pp. 141) U.S. Department of Commerce, National Oceanic and Atmospheric Administration and National Marine Fisheries Service.

Balazs, G., and M. Chaloupka (2006). Recovery trend over 32 years at the Hawaiian Green sea turtle Rookery of French Frigate Shoals. Atoll Research Bulletin (543), 147-158.

Balazs, G. H., P. Craig, B. R. Winton, and R. K. Miya (1994). Satellite telemetry of green sea turtles nesting at French Frigate Shoals, Hawaii, and Rose Atoll, American Samoa. In K. A. Bjorndal, A. B. Bolten, D. A. Johnson and P. J. Eliazar (Eds.), Proceedings of the Fourteenth Annual Symposium on Sea Turtle Biology and Conservation. (NOAA Technical Memorandum NMFS-SEFSC-351, pp. 184-187) U.S. Department of Commerce, National Oceanic and Atmospheric Administration and National Marine Fisheries Service.

Balcomb, K. C. (1987). The whales of Hawaii, including all species of marine mammals in Hawaiian and adjacent waters. San Francisco: Marine Mammal Fund.

Baldwin, R. M., M. Gallagher, and K. Van Waerebeek (1999). A review of cetaceans from waters off the Arabian Peninsula. In: The Natural History of Oman: A Festschrift for Michael Gallagher. M. Fisher, S. A. Ghazanfur and J. A. Soalton, Backhuys Publishers**:** 161-189.

Barlow, J. (2006). "Cetacean abundance in Hawaiian waters estimated from a summer/fall survey in 2002." Marine Mammal Science 22(2): 446-464.

Barlow, J. (2003). *Cetacean Abundance in Hawaiian Waters During Summer/Fall 2002*. La Jolla, CA, Southwest Fisheries Science Center, National Marine Fisheries Service and NOAA**:** 22.

Barlow, J., and R. Gisiner (2006). Mitigating, monitoring and assessing the effects of anthropogenic sound on beaked whales. Journal of Cetacean Research and Management, 7(3), 239-249.

Barlow, J., J. Calambokidis, E. A. Falcone, C. S. Baker, A. M. Burdin, P. J. Clapham, J. K. B. Ford, C. M. Gabriele, R. LeDuc, D. K. Mattila, T. J. Quinn II, L. Rojas-Bracho, J. M. Straley, B. L. Taylor, J. R. Urban, P. Wade, D. Weller, B. H. Witteveen, M. Yamaguchi (2011). Humpback whale abundance in the North Pacific estimated by photographic capture-recapture with bias correction from simulation studies. Marine Mammal Science, 1-26.

Barlow, J., M. Ferguson, E. Becker, J. Redfern, K. Forney, I. Vilchis, P. Fiedler, T. Gerrodette, and L. Ballance (2009). Predictive Modeling of Cetacean Densities in the Eastern Pacific Ocean. NOAA-TMNMFS-SWFSC-444, Southwest Fisheries Science Center, La Jolla, California.

Barlow, J., S. Rankin, A. Jackson, and A. Henry (2008). *Marine Mammal Data Collected During the Pacific Islands Cetacean and Ecosystem Assessment Survey (PICEAS) Conducted Aboard the NOAA Ship McArthur II, July-November 2005*, NOAA**:** 27.

Barlow, J., M. C. Ferguson, W. F. Perrin, L. Ballance, T. Gerrodette, G. Joyce (2006). "Abundance and densities of beaked and bottlenose whales (family Ziphiidae)." Journal of Cetacean Research and Management 7(3): 263-270.

Barlow, J., S. Rankin, E. Zele, and J. Appler (2004). *Marine Mammal Data Collected During the Hawaiian Islands Cetacean and Ecosystem Assessment Survey (HICEAS) Conducted Aboard the NOAA ships McArthur and David Starr Jordan, July-December 2002*, NOAA**:** 32.

Barros, N. B., and A. A. Myrberg (1987). "Prey detection by means of passive listening in bottlenose dolphins (*Tursiops truncatus*)." Journal of the Acoustical Society of America 82: S65.

Barros, N. B., and R. S. Wells (1998). "Prey and feeding patterns of resident bottlenose dolphins (*Tursiops truncatus*) in Sarasota Bay, Florida." Journal of Mammalogy 79(3): 1045-1059.

Bartol, S. M., and D. R. Ketten (2006). Turtle and tuna hearing. In Y. Swimmer and R. W. Brill (Eds.), Sea Turtle and Pelagic Fish Sensory Biology: Developing Techniques to Reduce Sea Turtle Bycatch in Longline Fisheries (NOAA Technical Memorandum NMFS-PIFSC-7, pp. 98-103) U.S. Department of Commerce, NOAA.

Bartol, S. M., J. A. Musick, M. L. Lenhardt (1999). Auditory evoked potentials of the loggerhead sea turtle (*Caretta caretta*). Copeia:836-840.

Baumgartner, M. F. (1997). "The distribution of Risso's dolphin (*Grampus griseus*) with respect to the physiography of the northern Gulf of Mexico." Marine Mammal Science 13(4): 614-638.

Beatson, E. (2007). "The diet of pygmy sperm whales, Kogia breviceps, stranded in New Zealand: Implications for conservation." Reviews in Fish Biology and Fisheries 17: 295-303.

Beavers, S. C., and E. R. Cassano (1996). Movement and dive behavior of a male sea turtle (*Lepidochelys olivacea*) in the eastern tropical Pacific. J. Herpetol. 30(1):97-104.

Becker, N. M. (1995). *Fate of Selected High Explosives in the Environment: A Literature Review*. Los Alamos National Laboratory. LAUR-95-1018. March 1995.

Becker, E. A., K. A. Forney, D. G. Foley, and J. Barlow (2012). "Density and spatial distribution patterns of cetaceans in the central North Pacific based on habitat models." U.S. Department of Commerce NOAA Technical Memorandum NMFS-SWFSC-490, 34 p.

Benoit-Bird, K. J. (2004). "Prey caloric value and predator energy needs: Foraging predictions for wild spinner dolphins." Marine Biology 145: 435-444.

Benoit-Bird, K. J., and W. W. L. Au (2003). "Prey dynamics affect foraging by a pelagic predator (*Stenella longirostris*) over a range of spatial and temporal scales." Behavioral Ecology and Sociobiology 53: 364-373.

Benoit-Bird, K. J., W. W. Au, R. E. Brainard, and M. O. Lammers (2001). "Diel horizontal migration of the Hawaiian mesopelagic boundary community observed acoustically." Marine Ecology Progress Series 217: 1-14.

Benson, S. R., K. A. Forney, J. T. Harvey, J. V. Carretta, and P. H. Dutton (2007). Abundance, distribution, and habitat of leatherback turtles (Dermochelys coriacea) off California, 1990-2003. Fishery Bulletin, 105(3), 337-347.

Bernard, H. J., and S. B. Reilly (1999). Pilot whales *Globicephala* Lesson, 1828. In: Handbook of Marine Mammals. S. H. Ridgway and R. Harrison. San Diego, CA, Academic Press. 6**:** 245-280.

Berzin, A. A., and V. L. Vladimirov (1981). "Changes in abundance of whalebone whales in the Pacific and Antarctic since the cessation of their exploitation." Reports of the International Whaling Commission 31: 495-499.

Best, P. B. (1996). "Evidence of migration by Bryde's whales from the offshore population in the southeast Atlantic." Reports of the International Whaling Commission 46: 315-322.

Best, P. B., and C. H. Lockyer. (2002). "Reproduction, growth and migrations of sei whales *Balaenoptera borealis* off the west coast of South Africa in the 1960s." South African Journal of Marine Science 24: 111-133.

Best, P. B., R. A. Rademeyer, C. Burton, D. Ljungblad, K. Sekiguchi, H. Shimada, D. Thiele, D. Reeb, and D. S. Butterworth (2003). "The abundance of blue whales on the Madagascar Plateau, December 1996." Journal of Cetacean Research and Management 5(3): 253-260.

Best, P. B., D. S. Butterworth, and L. H. Rickett (1984). "An assessment cruise for the South African inshore stock of Bryde's whales (*Balaenoptera edeni*)." Reports of the International Whaling Commission 34: 403-423.

Bjorndal, K. A. (2003). Roles of loggerhead sea turtles in marine ecosystems. In A. B. Bolten and B. E. Witherington (Eds.), Loggerhead Sea Turtles (pp. 235-254). Washington, DC: Smithsonian Institution Press.

Bjorndal, K. A. (1997). Foraging ecology and nutrition of sea turtles. In P. L. Lutz and J. A. Musick (Eds.), The Biology of Sea Turtles (pp. 199-231). Boca Raton, FL: CRC Press.

Bjorndal, K. A. (1995). The consequences of herbivory for the life history pattern of the green sea turtle, Chelonia mydas. In K. A. Bjorndal (Ed.), Biology and Conservation of Sea Turtles (Revised ed., pp. 111-116). Washington, DC: Smithsonian Institution Press.

Bjorndal, K. A., and A. B. Bolten (1988). Growth rates of immature green sea turtles, *Chelonia mydas*, on feeding grounds in the southern Bahamas. Copeia, 1988(3), 555-564.

Bloodworth, B., and D. K. Odell (2008). "Kogia breviceps." Mammalian Species 819: 1-12.

Blumenthal, J. M., T. J. Austin, J. B. Bothwell, A. C. Broderick, G. Ebanks-Petrie, J. R. Olynik, B. J. Godley (2009). Diving behavior and movements of juvenile hawksbill turtles *Eretmochelys imbricata* on a Caribbean coral reef. Coral Reefs, 28(1), 55-65. doi: 10.1007/s00338-008-0416-1.

Boggs, C. H., E. M. Oleson, K. A. Forney, B. Hanson, D. R. Kobayashi, B. L. Taylor, G. M. Ylitalo (2010). Status Review of Hawaiian Insular False Killer Whales (Pseudorca crassidens) under the Endangered Species Act. (NOAA Technical Memorandum NMFS-PIFSC-22, pp. 140 + Appendices) U. S. Department of Commerce and National Oceanic and Atmospheric Administration.

Bolle, L. J., C. A. F. de Jong, S. M. Bierman, P. J. G. van Beek, and O. A. van Keken (2012). Common Sole Larvae Survive High Levels of Pile-Driving Sound in Controlled Exposure Experiments. PLoS ONE 7(3): e33052. doi:10.1371/journal.pone.0033052.

Bolten, A. B. (2003). Variation in sea turtle life history patterns: Neritic vs. oceanic developmental stages. In P. L. Lutz, J. A. Musick and J. Wyneken (Eds.), The Biology of Sea Turtles (Vol. II, pp. 243-258). Boca Raton, FL: CRC Press.

Bowen, B. W., A. M. Clark, A. F. Abreu-Grobois, A. Chaves, H. A. `Reichart, and R. J. Ferl (1998). Global phylogeography of the ridley sea turtles (Lepidochelys spp.) As inferred from mitochondrial DNA sequences. Genetica, 101, 179-189.

Bowen, B. W., and S. A. Karl (1997). Population genetics, phylogeography, and molecular evolution. In P. L. Lutz and J. A. Musick (Eds.), The Biology of Sea Turtles (pp. 29-50). Boca Raton, FL: CRC Press.

Bowen, B. W., F. A. Abreu-Grobois, G. H. Balazs, N. Kamezaki, C. J. Limpus, and R. J. Ferl (1995). Trans-Pacific migrations of the loggerhead turtle (*Caretta caretta*) demonstrated with mitochondrial DNA markers. Proceedings of the National Academy of Sciences of the United States of America, 92, 3731-3734.

Bradford, A. L., and E. Lyman (2015). Injury determinations for humpback whales and other cetaceans reported to NOAA response networks in the Hawaiian Islands during 2007-2012. U.S. Department of Commerce, NOAA Technical Memoranda, NOAA-TM-NMFS-PIFSC-45, 29p.

Bradford, A. L., K. A. Forney, E. M. Oleson, and J. Barlow. *In Review*. *Line-transect abundance estimates of cetaceans in the Hawaiian EEZ.* Fisheries Bulletin.

Bradford, A. L., E. M. Oleson, R. W. Baird, C. H. Boggs, K. A. Forney, and N. C. Young (2015). Revised Stock Boundaries for False Killer Whales (*Pseuorca crassidens*) in Hawaiian Waters. NOAA Technical Memorandum NMFS-PIFSC-47. September 2015.

Bradford. A. L., K. A. Forney, E. M. Oleson, and J. Barlow (2013). Line-transect abundance estimates of cetaceans in the Hawaiian EEZ. PIFSC Working Paper WP-13-004.

Bradford, A. L., K. A. Forney, E. M. Oleson, and J. Barlow (2012). Line-transect abundance estimates of false killer whales (*Pseudorca crassidens*) in the pelagic region of the Hawaiian Exclusive Economic Zone and in the insular waters of the Northwestern Hawaiian Islands. Pacific Islands Fisheries Science Center, National Marine Fisheries Service, NOAA, Honolulu, HI 96822-2396. Pacific Islands Fish. Sci. Cent. Admin. Rep. H-12-02.

Bradshaw, C. J. A., C. R. McMahon, and G. C. Hays (2007). Behavioral inference of diving metabolic rate in free-ranging leatherback turtles. Physiological and Biochemical Zoology 80(2), 209-219.

Bresette, M., D. Singewald, and E. De Maye (2006). Recruitment of post-pelagic green sea turtles (*Chelonia mydas*) to nearshore reefs on Florida's east coast. In M. Frick, A. Panagopoulou, A. F. Rees and K. Williams (Eds.), Book of Abstracts: Twenty-sixth Annual Symposium on Sea Turtle Biology and Conservation (Abstract, pp. 288). Athens, Greece: International Sea Turtle Society.

Bresette, M., J. C. Gorham, and B. D. Peery (1998). Site fidelity and size frequencies of juvenile green turtles (*Chelonia mydas*) utilizing near shore reefs in St. Lucie County, Florida. Marine Turtle Newsletter, 82, 5-7. Retrieved from http://www.seaturtle.org/mtn/archives/mtn82/mtn82p5.shtml.

Brill, R. W., G. H. Balazs, K. N. Holland, R. K. C. Chang, S. Sullivan, and J. C. George (1995). Daily movements, habitat use, and submergence intervals of normal and tumor-bearing juvenile green sea turtles (*Chelonia mydas L*.) within a foraging area in the Hawaiian islands. Journal of Experimental Marine Biology and Ecology, 185(2), 203-218. doi: 10.1016/0022-0981(94)00146-5.

Brillinger, D. R., B. S. Stewart, and C. S. Littnan (2006). A meandering *hylje**. In Festschrift for Tarmo Pukkila on his 60th Birthday. E. P. Liski, J. Isotalo, J. Niemelä, S. Puntanen and G. P. H. Styan. Finland, Dept. of Mathematics, Statistics and Philosophy, University of Tampere**:** 79-92.

Brown, C. H., and W. M. Brown (1995). Status of sea turtles in the Southeastern Pacific: Emphasis on Peru. In K. A. Bjorndal (Ed.), Biology and Conservation of Sea Turtles (Revised ed., pp. 235-240). Washington DC: Smithsonian Institution Press.

Bull, J. C., P. D. Jepson, R. K. Ssuna, R. Deaville, C. R. Allchin, R. J. Law, and A. Fenton (2006). The relationship between polychlorinated biphenyls in blubber and levels of nematode infestations in harbour porpoises, Phocoena phocoena. Parasitology, 132, 565-573. doi:10.1017/S003118200500942X.

Byles, R. A. (1988). Behavior and ecology of sea turtles from Chesapeake Bay, Virginia (Ph.D. dissertation). College of William and Mary, Williamsburg, Virginia. Retrieved from http://www.sefsc.noaa.gov/PDFdocs/Byles_dissertation_1988.pdf.

Caillouet, C. W., C. T. Fontaine, S. A. Manzella-Tirpak, and D. J. Shaver (1995). Survival of head-started Kemp's ridley sea turtles (*Lepidochelys kempii*) released into the Gulf of Mexico or adjacent bays. *Chelonian Conservation and Biology 1*(4):285-292.

Calambokidis, J. (2009). Symposium on the results of the SPLASH humpback whale study: Final Report and Recommendations**:** 68.

Calambokidis, J., E. A. Falcone, T. J. Quinn, A. M. Burdin, P. J. Clapham, J. K. B. Ford, C. M. Gabriele, R. LeDuc, D. Mattila, L. Rojas-Bracho, J. M. Straley, B. L. Taylor, J. Urban R., D. Weller, B. H. Witteveen, M. Yamaguchi, A. Bendlin, D. Camacho, K. Flynn, A. Havron, J. Huggins, N. Maloney, J. Barlow, and P. R. Wade (2008). SPLASH: Structure of Populations, Levels of Abundance and Status of Humpback Whales in the North Pacific. Final report for Contract AB133F-03-RP-00078 prepared by Cascadia Research for U.S. Dept of Commerce.

Calambokidis, J., G. H. Steiger, J. M. Straley, S. Cerchio, D. R. Salden, J. R. Urban, J. K. Jacobsen, O. von Ziegesar, K. C. Balcomb, C. M. Gabriele, M. E. Dahlheim, S. Uchida, G. Ellis, Y. Miyamura, P. Ladron De Guevara, M. Yamaguchi, F. Sato, S. A. Mizroch, L. Schlender, K. Rasmussen, J. Barlow, and T. J. Quinn II (2001). “Movements and population structure of humpback whales in the North Pacific.” Marine Mammal Science 17(4): 769-794.

Caldwell, D. K., and M. C. Caldwell (1989). Pygmy sperm whale *Kogia breviceps* (de Blainville, 1838): Dwarf sperm whale *Kogia simus* Owen, 1866. In: Handbook of Marine Mammals. S. H. Ridgway and R. Harrison. San Diego, CA, Academic Press. 4: 234-260.

Canese, S., A. Cardinali, C. M. Foruntа, M. Giusti, G. Lauriano, E. Salvati, and S. Greco (2006). “The first identified winter feeding ground of fin whales (Balaenoperta physalus) in the Mediterranean Sea.” Journal of the Marine Biological Association of the United Kingdom 86(4): 903-907.

Canadas, A., R. Sagarminaga, and S. Garcia-Tiscar (2002). “Cetacean distribution related with depth and slope in the Mediterranean waters off southern Spain.” Deep Sea Research I 49: 2053-2073.

Carr, A. (1987). New perspectives on the pelagic stage of sea turtle development. Conservation Biology, 1(2), 103-121.

Carr, A. (1986). Rips, FADS, and little loggerheads. BioScience, 36(2), 92-100.

Carr, A., and A. B. Meylan (1980). Evidence of passive migration of green sea turtle hatchlings in Sargassum. Copeia, 1980(2), 366-368.

Carr, A., M. Carr, and A. B. Meylan (1978). The ecology and migrations of sea turtles, 7. The west carribean green sea turtle colony. Bulletin of the American Museum of Natural History, 162(1), 1-46.

Carretta, J. V., E. M. Oleson, D. W. Weller, A. R. Lang, K. A. Forney, J. Baker, M. M. Muto, B. Hanson, A. J. Orr, H. Huber, M. S. Lowry, J. Barlow, J. E. Moore, D. Lynch, L. Carswell, and R. L. Brownell Jr. (2015). U.S. Pacific Marine Mammal Stock Assessments: 2014. U.S. Department of Commerce, NOAA Technical Memorandum, NOAA-TMNMFS-SWFSC-549. 414 p.

Carretta, J. V., K. A. Forney, E. Oleson, K. Martien, M. M. Muto, M. S. Lowry, J. Barlow, J. Baker, B. Hanson, D. Lynch, L. Carswell, R. L. Brownell, J. Robbins, D. K. Mattila, K. Ralls, and M. C. Hill (2011). *U.S. Pacific Marine Mammal Stock Assessments: 2010*. La Jolla, CA, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center**:** 352.

Carretta, J. V., K. A. Forney, M. S. Lowry, J. Barlow, J. Baker, D. Johnston, B. Hanson, R. L. Brownell Jr., J. Robbins, D. Mattila, K. Ralls, M. M. Muto, D. Lynch, and L. Carswell (2010). *U.S. Pacific Marine Mammal Stock Assessments: 2009. La Jolla, CA, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center**:** 336.*

Carretta, J. V., T. Price, D. Petersen, and R. Read (2005). “Estimates of marine mammal, sea turtle, and seabird mortality in the California drift gillnet fishery for swordfish and thresher shark, 1996-2002.” Marine Fisheries Review 66(2): 21-30.

Cascadia Research (2012a). *An update on our June/July 2012 Kaua'i field work,* Cascadia Research Collective. http://www.cascadiaresearch.org/hawaii/july2011.htm.

Cascadia Research (2012b). Beaked Whales in Hawai'i, Cascadia Research. http://www.cascadiaresearch.org/hawaii/beakedwhales.htm.

Cascadia Research (2010). *Hawai'i's false killer whales*, Cascadia Research. 2010.

Cetacean and Turtle Assessment Program (1982). "A Characterization of Marine Mammals and Turtles in the Mid- and North Atlantic Areas of the U.S. Outer Continental Shelf." 540.

Chaloupka, M. Y., and J. A. Musick (1997). Age, growth, and population dynamics. In P. L. Lutz and J. A. Musick (Eds.), The Biology of Sea Turtles (pp. 233-276). Boca Raton, FL: CRC Press.

Chaloupka, M., T. M. Work, G. Balazs, S. K. Murakawa, and R. Morris (2008a). Cause-specific temporal and spatial trends in green sea turtle strandings in the Hawaiian Archipelago (1982-2003). Marine Biology, 154, 887-898.

Chaloupka, M., N. Kamezaki, and C. Limpus (2008b). Is climate change affecting the population dynamics of the endangered Pacific loggerhead sea turtle? Journal of Experimental Marine Biology and Ecology, 356(1-2), 136-143. doi: 10.1016/j.jembe.2007.12.009.

Chaloupka, M., P. Dutton, and H. Nakano (2004). Status of sea turtle stocks in the Pacific. In Papers Presented at the Expert Consultation on Interactions between Sea Turtles and Fisheries Within an Ecosystem Context (FAO Fisheries Report No. 738, Supplement, pp. 135-164). Rome, Italy: Food and Agriculture Organization of the United Nations.

Chivers, S. J., R. W. Baird, K. M. Martien, B. L. Taylor, E. Archer, A. M. Gorgone, B. L. Hancock, N. M. Hedrick, D. Matilla, D. J. McSweeney, E. M. Oleson, C. L. Palmer, V. Pease, K. M. Robertson, J. Robbins, J. C. Salinas, G. Schorr, M. Schultz, J. L. Thieleking, and D. L. Webster (2010). "Evidence of genetic differentiation for Hawaii insular false killer whales (*Pseudorca crassidens*)." NOAA Technical Report NMFS NOAA-TM-NMFS-SWFSC-458: 49.

Chivers, S. J., R. W. Baird, D. J. McSweeney, D. L. Webster, N. M. Hedrick, and J. C. Salinas (2007). "Genetic variation and evidence for population structure in eastern North Pacific false killer whales (*Pseudorca crassidens*)." Canadian Journal of Zoology 85: 783-794.

Chua, T. H. (1988). Nesting population and frequency of visits in Dermochelys coriacea in Malaysia. Journal of Herpetology, 22(2), 192-207.

Craig, A. S., and L. M. Herman (2000). "Habitat preferences of female humpback whales Megaptera novaeangliae in the Hawaiian Islands are associated with reproductive status." Marine Ecology Progress Series 193: 209-216.

Clapham, P. J. (2000). The humpback whale: seasonal feeding and breeding in a baleen whale. In: Cetacean Societies: Field Studies of Dolphins and Whales. J. Mann, R. C. Connor, P. L. Tyack and H. Whitehead, University of Chicago Press: 173-196.

Clapham, P. J., and D. K. Mattila (1990). "Humpback whale songs as indicators of migration routes." Marine Mammal Science 6(2): 155-160.

Clapham, P. J., and J. G. Mead (1999). "Megaptera novaeangliae." Mammalian Species 604: 1-9.

Clark, S. L., J. W. Ward (1943) The Effects of Rapid Compression Waves on Animals Submerged In Water. Surgery, Gynecology & Obstetrics 77:403-412.

Clarke, M. R. (1996). "Cephalopods as prey. III. Cetaceans." Philosophical Transactions of the Royal Society of London 351: 1053-1065.

Cliffton, K., D. O. Cornejo, and R. S. Felger (1995). Sea turtles of the Pacific coast of Mexico. In K. A. Bjorndal (Ed.), Biology and Conservation of Sea Turtles (Revised ed., pp. 199-209). Washington, DC: Smithsonian Institution Press.

Conant, T. A., P. H. Dutton, T. Eguchi, S. P. Epperly, C. C. Fahy, M. H. Godfrey, B. E. Witherington (2009). Loggerhead Sea Turtle (*Caretta caretta*) 2009 Status Review under the U.S. Endangered Species Act (pp. 222). Loggerhead Biological Review Team and National Marine Fisheries Service.

Continental Shelf Associates (CSA) (2004). Explosive removal of offshore structures – information synthesis report. U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2003-070. 181 pp. + app.

Cox, T., T. Ragen, A. Read, E. Vox, R. Baird, K. Balcomb, L. Benner (2006). Understanding the impacts of anthropogenic sound on beaked whales. Journal of Cetacean Research and Management, 7(3), 177-187.

Cummings, W. C. (1985). Bryde's whale *Balaenoptera edeni* Anderson, 1878. In: Handbook of Marine Mammals. S. H. Ridgway and R. Harrison. San Diego, CA, Academic Press. 3**:** 137-154.

D'Vincent, C. G., R. M. Nilson, and R. E. Hanna (1985). "Vocalization and coordinated feeding behavior of the humpback whale in southeastern Alaska." Scientific Reports of the Whales Research Institute 36: 41-47.

Dahlheim, M. E., and J. E. Heyning (1999). Killer whale *Orcinus orca* (Linnaeus, 1758). In: Handbook of Marine Mammals. S. H. Ridgway and R. Harrison. San Diego, CA, Academic Press. 6**:** 281-322.

Dalebout, M. L., G. J. B. Ross, C. S. Baker, R. C. Anderson, P. B. Best, V. G. Cockcroft, H. L. Hinsz, V. M. Peddemors, and R. L. Pitman (2003). "Appearance, distribution and genetic distinctiveness of Longman's beaked whale, *Indopacetus pacificus*." Marine Mammal Science 19(3): 421-461.

Dalebout, M. L., J. G. Mead, C. S. Baker, A. N. Baker, and A. L. van Helden (2002). "A new species of beaked whale *Mesoplodon perrini* sp. n. (Cetacea: Ziphiidae) discovered through phylogenetic analyses of mitochondrial DNA sequences." Marine Mammal Science 18(3): 577-608.

Darrach, M. R., A. Chutjian, and G. A. Plett (1998). Trace Explosives Signatures from World War II Unexploded Undersea Ordnance. Environmental Science Technology, 1998, 32(9), pp 1354-1358. DOI: 10.1021/es970992h.

Davenport, J. (1988). Do diving leatherbacks pursue glowing jelly? British Herpetological Society Bulletin, 24, 20-21.

Davenport, J., and G. H. Balazs (1991). 'Fiery bodies' Are pyrosomas an important component of the diet of leatherback turtles? British Herpetological Society Bulletin, 37, 33-38.

Davis, R. W., N. Jaquet, D. Gendron, U. Markaida, G. Bazzino, and W. Gilly (2007). "Diving behavior of sperm whales in relation to behavior of a major prey species, the jumbo squid, in the Gulf of California, Mexico." Marine Ecology Progress Series 333: 291-302.

Davis, R. W., W. E. Evans, and B. Wursig (2000). *Cetaceans, Sea Turtles and Seabirds in the Northern Gulf of Mexico: Distribution, Abundance and Habitat Associations. Volume II: Technical report*. New Orleans, LA, U.S. Department of the Interior, Geological Survey, Biological Resources Division, and Minerals Management Service, Gulf of Mexico OCS Region**:** 346.

Davis, R. W., G. S. Fargion, N. May, T. D. Leming, M. Baumgartner, W. E. Evans, L. J. Hansen, and K. Mullin (1998). "Physical habitat of cetaceans along the continental slope in the north-central and western Gulf of Mexico." Marine Mammal Science 14(3): 490-507.

Debusschere, Elisabeth, Kris Hostens, Dominique Adriaens, Bart Ampe, Dick Botteldooren, Gadrun De Boeck, Amelie De Muynck, Amit Kumar Sinha, Sofie Vandendriessche, Luc Van Hoorebeke, Magda Vincx, and Steven Degraer (2015). Acoustic stress responses in juvenile sea bass Dicentrarchus labrax induced by offshore pile driving. Environmental Pollution 208 (2016) 747-757.

Department of the Navy (2015). *Hawaii-Southern California Training and Testing (HSTT) - 2014 Annual Monitoring Report*. Prepared by Commander, U.S. Pacific Fleet, Pearl Harbor, Hawaii. Prepared for and submitted to National Marine Fisheries Service, Silver Spring, MD.

Department of the Navy (2013). Hawaii-Southern California Testing and Training EIS/OEIS. Final EIS/OEIS August 2013.

Department of the Navy (2012). Request for Letters of Authorization for the Incidental Harassment of Marine Mammals Resulting from U.S. Navy Training and Testing Activities in the Hawaii-Southern California Training and Testing Study Area. Submitted to Office of Protected Resources, National Marine Fisheries Service, Silver Spring, MD. Submitted by Commander, United States Pacific Fleet, Pearl Harbor, HI. 24 September 2012.

Department of the Navy (2008). Barking Sands Underwater Range Expansion (BSURE) Refurbishment. Final Record of Categorical Exclusion/Overseas Environmental Assessment. March 2008.

Department of the Navy (DON) (1998). *Final Environmental Impact Statement, Shock-testing the SEAWOLF Submarine*. Washington, D.C.

DeRuiter, S. L., and K. L. Doukara (2012). Loggerhead turtles dive in response to airgun sound exposure. endangered Species Research. Vol. 16: 55-63. doi: 10.3354/esr00396.

Dobbs, K. A., J. D. Miller, C. J. Limpus, and A. M. Landry Jr. (1999). Hawksbill turtle, *Eretmochelys imbricata*, nesting at Milman Island, northern Great Barrier Reef, Australia. Chelonian Conservation and Biology, 3(2), 344-361.

Dodd, C. K., Jr. (1988). Synopsis of the Biological Data on the Loggerhead Sea Turtle *Caretta caretta* (Linnaeus 1758). (Biological Report 88(14), pp. 110). Washington, D.C.: U.S. Fish and Wildlife Service.

Dolar, M. L. L. (2008). Fraser's dolphin *Lagenodelphis hosei*. In: Encyclopedia of Marine Mammals. W. F. Perrin, B. Würsig and J. G. M. Thewissen. San Diego, CA, Academic Press**:** 485-487.

Donohue, M. J., and D. G. Foley (2007). "Remote sensing reveals links among the endangered Hawaiian monk seal, marine debris and El Niño." Marine Mammal Science 23(2): 468–473.

Donahue, M. A., and W. L. Perryman (2008). Pygmy killer whale Feresa attenuata. In: Encyclopedia of Marine Mammals. W. F. Perrin, B. Würsig and J. G. M. Thewissen. San Diego, CA, Academic Press: 938-939.

Donovan, G. P. (1991). "A review of IWC stock boundaries." Reports of the International Whaling Commission Special Issue 13: 39-68.

Dunphy-Daly, M. M., M. R. Heithaus, and D. E. Claridge (2008). "Temporal variation in dwarf sperm whale (*Kogia sima*) habitat use and group size off Great Abaco Island, Bahamas." Marine Mammal Science 24(1): 171-182.

Dutton, P. H. (unpublished data, 5 February). Sea turtle satellite data inquiry. K. Kelly, Tetra Tech, Inc, Honolulu, HI.

Dutton, P. (2006). Building our knowledge of the leatherback stock structure. SWoT Report-State of the World's Sea Turtles, I, 10-11. Retrieved from http://seaturtlestatus.org/report/swot-volume-1.

Dutton, P. H., B. W. Bowen, D. W. Owens, A. Barragan, and S. K. Davis (1999). Global phylogeography of the leatherback turtle (Dermochelys coriacea). Journal of Zoology, London, 248, 397-409.

Dutton, P. H., G. H. Balazs, and A. E. Dizon (1998). Genetic stock identification of sea turtles caught in the Hawaii-based pelagic longline fishery. In S. P. Epperly and J. Braun (Eds.), Proceedings of the Seventeenth Annual Sea Turtle Symposium [Abstract]. (NOAA Technical Memorandum NMFS-SEFSC-415, pp. 45-46). U. S. Department of Commerce, National Oceanic and Atmospheric Administration and National Marine Fisheries Service. Available from http://www.nmfs.noaa.gov/pr/species/turtles/symposia.htm.

Eckert, S. A. (2002). Distribution of juvenile leatherback sea turtle Dermochelys coriacea sightings. Marine Ecology Progress Series, 230, 289-293.

Eckert, K. L. (1995). Anthropogenic threats to sea turtles. In K. A. Bjorndal (Ed.), Biology and Conservation of Sea Turtles (Revised ed., pp. 611-612). Washington, DC: Smithsonian Institution Press.

Eckert, K. L. (1993). The Biology and Population Status of Marine Turtles in the North Pacific Ocean. (NOAA-TM-NMFS-SWFSC-186, pp. 166) U.S. Department of Commerce, National Oceanic and Atmospheric Administration and National Marine Fisheries Service.

Eckert, K. L. (1987). Environmental unpredictability and leatherback sea turtle (Dermochelys coriacea) nest loss. Herpetologica, 43(3), 315-323.

Eckert, K. L., and S. A. Eckert (1988). Pre-reproductive movements of leatherback sea turtles (*Dermochelys coriacea*) nesting in the Caribbean. Copeia, 1988(2), 400-406.

Eckert, S. A., and L. Sarti-Martinez (1997). Distant fisheries implicated in the loss of the world's largest leatherback nesting population. Marine Turtle Newsletter, 78, 2-7. Retrieved from http://www.seaturtle.org/mtn/archives/mtn78/mtn78p2.shtml.

Eckert, K. L., K. A. Bjorndal, F. A. Abreu-Grobois, and M. Donnelly (Eds.) (1999). Research and Management Techniques for the Conservation of Sea Turtles. (IUCN/SSC Marine Turtle Specialist Group Publication No. 4, pp. 24).

Eckert, S. A., H. C. Liew, K. L. Eckert, and E. H. Chan (1996). Shallow water diving by leatherback turtles in the South China Sea. Chelonian Conservation and Biology, 2(2), 237-243.

Eckert, K. L., S. A. Eckert, T. W. Adams, and A. D. Tucker (1989). Inter-nesting migrations by leatherback sea turtles (*Dermochelys coriacea*) in the West Indies. Herpetologica, 45(2), 190-194.

Eckert, S. A., K. L., Eckert, P. Ponganis, and G. L. Kooyman (1989). Diving and foraging behavior of leatherback sea turtles (*Dermochelys coriacea*). Canadian Journal of Zoology, 67, 2834-2840.

Eckert, S. A., D. W. Nellis, K. L. Eckert, and G. L. Kooyman (1986). Diving patterns of two leatherback sea turtles (Dermochelys coriacea) during internesting intervals at Sandy Point, St. Croix, U.S. Virgin Islands. Herpetologica, 42(3), 381-388.

Eisenberg, J. F., and J. Frazier (1983). A leatherback turtle (*Dermochelys coriacea*) feeding in the wild. Journal of Herpetology, 17(1), 81-82.

Erbe C., A. MacGillivray, and R. Williams (2012). Mapping cumulative noise from shipping to inform marine spatial planning. *Journal of the Acoustical Society of America*, 132(5): 423-428.

Ersts, P. J., and H. C. Rosenbaum (2003). "Habitat preference reflects social organization of humpback whales (Megaptera novaeangliae) on a wintering ground." Journal of Zoology, London 260: 337-345.

Fair, P. A., J. Adams, G. Mitchum, T. C. Hulsey, J. S. Reif, M. Houde, G. D. Bossart (2010). Contaminant blubber burdens in Atlantic bottlenose dolphins (*Tursiops truncatus*) from two southeastern US estuarine areas: Concentrations and patterns of PCBs, pesticides, PBDEs, PFCs, and PAHs. *Science of the Total Environment, 408*, 1577-1597. doi:10.1016/j.scitotenv.2009.12.021.

Falcone, E., G. Schorr, A. Douglas, J. Calambokidis, E. Henderson, M. McKenna, J. Hildebrand, and D. Moretti (2009). "Sighting characteristics and photo-identification of Cuvier's beaked whales (*Ziphius cavirostris*) near San Clemente Island, California: A key area for beaked whales and the military?" Marine Biology 156: 2631-2640.

Fauquier, D. A., M. J. Kinsel, M. D. Dailey, G. E. Sutton, M. K. Stolen, R. S. Wells and F. M. D. Gulland (2009). Prevalence and pathology of lungworm infection in bottlenose dolphins Tursiops truncatus from southwest Florida. Diseases Of Aquatic Organisms, 88, 85-90. doi: 10.3354/dao02095.

Ferguson, M. C. (2005). *Cetacean Population Density in the Eastern Pacific Ocean: Analyzing Patterns With Predictive Spatial Models* Ph.D., University of California, San Diego.

Ferguson, M. C., J. Barlow, S. B. Reilly, and T. Gerrodette (2006b). "Predicting Cuvier's (*Ziphius cavirostris*) and *Mesoplodon* beaked whale population density from habitat characteristics in the eastern tropical Pacific Ocean." Journal of Cetacean Research and Management 7(3): 287-299.

Ferguson, M. C., J. Barlow, T. Gerrodette, and P. Fiedler (2001). Meso-scale patterns in the density and distribution of ziphiid whales in the eastern Pacific Ocean. Fourteenth Biennial Conference on the Biology of Marine Mammals, Vancouver, British Columbia.

Finneran, J. J., D. A. Carder, C. E. Schlundt, and S. H. Ridgway (2005). Temporary Threshold Shift in Bottlenose Dolphins (*Tursiops truncatus*) Exposed to Mid-frequency Tones. Journal of the Acoustical Society of America 118:2696-2705.

Finneran, J. J., C. E. Schlundt, R. Dear, D. A. Carder, and S. H. Ridgway (2002). Temporary Shift in Masked Hearing Thresholds in Odontocetes After Exposure to Single Underwater Impulses from a Seismic Watergun. Journal of the Acoustical Society of America 111:2929-2940.

Finneran, J. J., C. E. Schlundt, D. A. Carder, J. A. Clark, J. A. Young, J. B. Gaspin, S. H. Ridgway (2000). Auditory and Behavioral Responses of Bottlenose Dolphins (*Tursiops truncatus*) and a Beluga Whale (*Delphinapterus leucas*) to Impulsive Sounds Resembling Distant Signatures of Underwater Explosions. Journal of the Acoustical Society of America 108:417-431.

Finneran, J. J., and A. K. Jenkins (2012). Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis. U.S. Navy, SPAWAR Systems Center. April.

Finneran, J. J. and C. E. Schlundt (2004). Effects of intense pure tones on the behavior of trained odontocetes [Technical Report]. (Vol. TR 1913). San Diego, CA: SSC San Diego.

Ford, J. K. B. (2008). Killer whale *Orcinus orca*. In: Encyclopedia of Marine Mammals. W. F. Perrin, B. Würsig and J. G. M. Thewissen. San Diego, CA, Academic Press**:** 650-657.

Ford, J. K. B., G. M. Ellis, P. F. Olesiuk, and K. C. Balcomb (2009). Linking killer whale survival and prey abundance: food limitation in the oceans' apex predator. Biol. Lett.

Ford, J. K. B., G. M. Ellis, D. R. Matkin, K. C. Balcomb, D. Briggs, and A. B. Morton (2005). "Killer whale attacks on minke whales: Prey capture and antipredator tactics." Marine Mammal Science 21(4):603-618.

Forestell, P. H., and J. Urbán-Ramirez (2007). Movement of a Humpback Whale (*Megaptera novaeangliae*) between the Revillagigedo and Hawaiian Archipelagos within a Winter Breeding Season. LAJAM 6(1): 97-102.

Forney, K. A., E. A. Becker, D. G. Foley, J. Barlow, and E. M. Oleson (2015). Habitat-based models of cetacean density and distribution in the central North Pacific. *Endangered Species Research*. Vol 27:1-20, 2015. doi: 10.3354/esr00632.

Forney, K., R. Baird, and E. Oleson (2010). Rationale for the 2010 revision of stock boundaries for the Hawai'i insular and pelagic stocks of false killer whales, *Pseudorca crassidens*. NOAA Technical Memorandum, NOAA-TM-NMFS-SWFSC-471.

Fossette, S., S. Ferraroli, H. Tanaka, Y. Ropert-Coudert, N. Arai, K. Sato, J. Georges (2007). Dispersal and dive patterns in gravid leatherback turtles during the nesting season in French Guiana. Marine Ecology Progress Series 338, 233-247.

Frair, W., R. G. Ackman, and N. Mrosovsky (1972). Body temperature of Dermochelys coriacea: Warm turtle from cold water. Science, 177, 791-793.

Frantzis, A., J. C. Goold, E. K. Skarsoulis, M. I. Taroudakis, and V. Kandia (2002). "Clicks from Cuvier's beaked whales, *Ziphius cavirostris* (L)." Journal of the Acoustical Society of America 112(1): 34-37.

Frazier, J. G. (2001). General natural history of marine turtles. In K. L. Eckert and F. A. Abreu-Grobois (Eds.), Proceedings of the Marine Turtle Conservation in the Wider Caribbean Region: A Dialogue for Effective Regional Management. (pp. 3-17) WIDECAST, IUCN-MTSG, WWF and UNEP-CEP.

Fretey, J. (2001). Biogeography and Conservation of Marine Turtles of the Atlantic Coast of Africa. (CMS Technical Series Publication, no. 6, pp. 429). Bonn, Germany: UNEP/CMS Secretariat.

Fritts, T. H. (1981). Pelagic feeding habits of turtles in the eastern pacific. Marine Turtle Newsletter, 17(1), 4-5. Retrieved from http://www.seaturtle.org/mtn/archives/mtn17/mtn17p4.shtml.

Fritts, T. H., M. L. Stinson, and R. M. Márquez (1982). Status of sea turtle nesting in southern Baja California, México. Bulletin of the Southern California Academy of Sciences, 81(2), 51-60.

Fulling, G. L., P. H. Thorson, J. Rivers (2011). Distribution and Abundance Estimates for Cetaceans in the Waters off Guam and the Commonwealth of the Northern Mariana Islands. Official Journal of the Pacific Science Association, In press Pacific Science, 1-46.

Fulling, G. L., K. D. Mullin, and C. W. Hubard (2003). "Abundance and distribution of cetaceans in outer continental shelf waters of the U.S. Gulf of Mexico." Fishery Bulletin 101: 923-932.

Gallo-Reynoso, J. P., and A. L. Figueroa-Carranza (1995). "Occurrence of bottlenose whales in the waters of Isla Guadalupe, Mexico." Marine Mammal Science 11(4): 573-575.

Gannier, A. (2000). "Distribution of cetaceans off the Society Islands (French Polynesia) as obtained from dedicated surveys." Aquatic Mammals 26(2): 111-126.

Gannier, A., and E. Praca (2007). "SST fronts and the summer sperm whale distribution in the north-west Mediterranean Sea." Journal of the Marine Biological Association of the United Kingdom 87: 187-193.

Gannier, A., and K. L. West (2005). "Distribution of the rough-toothed dolphin (*Steno bredanensis*) around the Windward Islands, (French Polynesia)." Pacific Science 59: 17-24.

Geijer, C. K. A., and A. J. Read (2013). Mitigation of marine mammal bycatch in U.S. fisheries since 1994. Biological Conservation 159:54-60.

Gilman, E. (2008). Pacific Leatherback Conservation and Research Activities, Financing and Priorities. (pp. 31). Honolulu, HI: The World Conservation Union and Western Pacific Fishery Management Council and IUCN.

Gilman, E., Clarke, S., Brothers, N., Alfaro-Shigueto, J., Mandelman, J., Mangel, J., Werner, T. (2007). Shark Depredation and Unwanted Bycatch in Pelagic Longline Fisheries: Industry Practices and Attitudes, and Shark Avoidance Strategies. (pp. 164). Honolulu, HI: Western Pacific Regional Fishery Management Council.

Gilmartin, W. G., and J. Forcada (2009). Monk seals *Monachus monachus, M. tropicalis*, and *M. schauinslandi*. In: Encyclopedia of Marine Mammals. W. F. Perrin, B. Wursig and J. G. M. Thewissen, Academic Press**:** 741-744.

Godley, B. J., A. C. Broderick, F. Glen, and G. C. Hays (2003). Post-nesting movements and submergence patterns of loggerhead marine turtles in the Mediterranean assessed by satellite tracking. Journal of Experimental Marine Biology and Ecology, 287, 119-134.

Godley, B. J., D. R. Thompson, S. Waldron, and R. W. Furness (1998). The trophic status of marine turtles as determined by stable isotope analysis. Marine Ecology Progress Series, 166, 277-284.

Goertner, J. F. (1982). Prediction of Underwater Explosion Safe Ranges for Sea Mammals. Dahlgren, Virginia, Naval Surface Weapons Center: 25.

Goff, G. P., and G. B. Stenson (1988). Brown adipose tissue in leatherback sea turtles: A thermogenic organ in an endothermic reptile? Copeia, 1988(4), 1071-1075.

Goldbogen, J. A., J. Calambokidis, R. E. Shadwick, E. M. Oleson, M. A. McDonald, and J. A. Hildebrand (2006). "Kinematics of foraging dives and lunge-feeding in fin whales." Journal of Experimental Biology 209: 1231-1244.

Goodman-Lowe, G. D. (1998). Diet of the Hawaiian monk seal (*Monachus schauinslandi*) from the Northwestern Hawaiian Islands during 1991-1994. In: Marine Biology. 132**:** 535-546.

Grant, G. S., and D. Ferrell (1993). Leatherback turtle, *Dermochelys coriacea* (Reptilia: Dermochelidae): Notes on near-shore feeding behavior and association with cobia. Brimleyana, 19, 77-81.

Greaves F. C., R. H. Draeger, O. A. Brines, J. S. Shaver, E. L.Corey (1943). An Experimental Study of Concussion. United States Naval Medical Bulletin 41:339-352.

Green, G. A., J. J. Brueggeman, R. A. Grotefendt, C. E. Bowlby, M. L. Bonnell, and K. C. Balcomb III (1992). *Cetacean distribution and abundance off Oregon and Washington, 1989-1990*. Los Angeles, CA, Minerals Management Service**:** 100.

Greer, A. E., Jr., J. D. Lazell Jr., and R. M. Wright (1973). Anatomical evidence for a counter-current heat exchanger in the leatherback turtle (Dermochelys coriacea). Nature, 244, 181.

Gregr, E. J., and A. W. Trites (2001). "Predictions of critical habitat for five whale species in the waters of coastal British Columbia." Canadian Journal of Fisheries and Aquatic Sciences 58: 1265-1285.

Griffin, R. B., and N. J. Griffin (2004). "Temporal variation in Atlantic spotted dolphin (*Stenella frontalis*) and bottlenose dolphin (*Tursiops truncatus*) densities on the west Florida continental shelf." Aquatic Mammals 30(3): 380-390.

Hailman, J. P., and A. M. Elowson (1992). Ethogram of the nesting female loggerhead (*Caretta caretta*). Herpetologica, 48(1), 1-30.

Hamer, D. J., S. J. Childerhouse, and N. J. Gales (2010). Mitigating operational interactions between odontocetes and the longline fishing industry: A preliminary global review of the problem and of potential solutions. Tasmania, Australia, International Whaling Commission: 30.

Handley, C. O. (1966). A synopsis of the genus *Kogia* (pygmy sperm whales). In: Whales, Dolphins, and Porpoises. K. S. Norris, University of California Press: 62-69.

Hatase, H., K. `Omuta, and K. Tsukamoto (2007). Bottom or midwater: alternative foraging behaviours in adult female loggerhead sea turtles. Journal of Zoology, 273(1), 46-55. doi: 10.1111/j.1469-7998.2007.00298.x.

Hatase, H., K. Sato, M. Yamaguchi, K. Takahashi, and K. Tsukamoto (2006). Individual variation in feeding habitat use by adult female green sea turtles (Chelonia mydas): are they obligately neritic herbivores? Oecologia, 149(1), 52-64. doi: 10.1007/s00442-006-0431-2.

Hatase, H., Y. Matsuzawa, W. Sakamoto, N. Baba, and I. Miyawaki (2002). Pelagic habitat use of an adult Japanese male loggerhead turtle *Caretta caretta* examined by the Argos satellite system. Fisheries Science, 68, 945-947.

Hawaiian Islands Humpback Whale National Marine Sanctuary (2014). Hawaiian Islands Disentanglement Network. 2013-2014 Disentanglement Season Summary. Accessed at http://hawaiihumpbackwhale.noaa.gov/res/2014_disentanglement.html. Revised May 8, 2014.

Hawkes, L. A., A. C. Broderick, M. S. Coyne, M. H. Godfrey, L.-F. Lopez-Jurado, P. Lopez-Suarez, B. J. Godley (2006). Phenotypically linked dichotomy in sea turtle foraging requires multiple conservation approaches. Current Biology, 16, 990-995.

Hays, G. C., J. D. R. Houghton, C. Isaacs, R. S. King, C. Lloyd, and P. Lovell (2004a). First records of oceanic dive profiles for leatherback turtles, *Dermochelys coriacea*, indicate behavioural plasticity associated with long-distance migration. Animal Behaviour, 67, 733-743.

Hays, G. C., J. D. Metcalfe, and A. W. Walne (2004b). The implications of lung-regulated buoyancy control for dive depth and duration. Ecology, 85(4), 1137-1145.

Hazel, J., I. R. Lawler, H. Marsh, and S. Robson (2007). Vessel speed increases collision risk for the green sea turtle *Chelonia mydas*. Endangered Species Research, 3(2), 105-113. doi: 10.3354/esr003105.

HDR (2012). Summary Report: Compilation of Visual Survey Effort and Sightings for Marine Species Monitoring in the Hawaii Range Complex, 2005-2012. Prepared for Commander, U.S. Pacific Fleet, Pearl Harbor, Hawaii. Submitted to Naval Facilities Engineering Command Pacific (NAVFAC), EV2 Environmental Planning, Pearl Harbor, Hawaii, 96860-3134, under contract # N62470-10-D-3011, issued to HDR, Inc., San Diego, California, 92123.

Heithaus, M. R., J. J. McLash, A. Frid, L. M. Dill, and G. Marshall (2002). Novel insights into green sea turtle behaviour using animal-borne video cameras. Journal of the Marine Biological Association of the United Kingdom, 82(6), 1049-1050.

Herman, L. M., C. S. Baker, P. H. Forestell, and R. C. Antinoja (1980). Right Whale *Balaena glacialis* Sightings Near Hawaii: A Clue to the Wintering Grounds? Marine Ecology - Progress Series, 2, 271-275.

Hewitt, A. D., T. F. Jenkins, T. A. Ranney, J. A. Stark, M. E. Walsh, S. Taylor, M. R. Walsh, D. J. Lambert, N. M. Perron, N. H. Collins, and R. Karn (2003). Estimates for Explosives Residue from the Detonation of Army Munitions. U.S. Army Corps of Engineers ERDC/CRREL TR-03-16. September 2003.

Heyning, J. E. (1989). Cuvier's beaked whale *Ziphius cavirostris* G. Cuvier, 1823. In: Handbook of Marine Mammals. S. H. Ridgway and R. Harrison. San Diego, CA, Academic Press. 4**:** 289-308.

Heyning, J. E., and J. G. Mead (2008). Cuvier's beaked whale *Ziphius cavirostris*. In: Encyclopedia of Marine Mammals. W. F. Perrin, B. Wursig and J. G. M. Thewissen, Academic Press**:** 294-295.

Hickmott, L. S. (2005). *Diving behaviour and foraging behaviour and foraging ecology of Blainville's and Cuvier's beaked whales in the Northern Bahamas*. Master of Research in Environmental Biology Master's thesis, University of St. Andrews.

Hildebrand, J. A. (2009). Anthropogenic and natural sources of ambient noise in the ocean. Marine Ecology Progress Series, vol. 395: 5-20.

Hirth, H. F. (1997). Synopsis of the Biological Data on the Green sea turtle *Chelonia mydas* (Linnaeus 1758). (Biological Report 97(1)). Washington, DC: U.S. Fish and Wildlife Service.

Hirth, H. F., and Ogren, L. H. (1987). Some Aspects of the Ecology of the Leatherback Turtle *Dermochelys coriacea* at Laguna Jalova, Costa Rica. (NOAA Technical Report NMFS 56, pp. 14) U.S. Department of Commerce, National Oceanic and Atmospheric Administration and National Marine Fisheries Service.

Hirth, H., J. Kasu, and T. Mala (1993). Observations on a Leatherback Turtle *Dermochelys coriacea* Nesting Population near Piguwa, Papua New Guinea. Biological Conservation, 65, 77-82.

Hoffsommer, J. C., D. J. Glover, and J. M. Rosen (1972). Analysis of Explosives in Sea Water and in Ocean Floor Sediment and Fauna. Naval Ordnance Laboratory, White Oak, Silver Spring, MD. NOTLR 72-215. September 1972.

Horwood, J. (2009). Sei whale *Balaenoptera borealis*. In: Encyclopedia of Marine Mammals. W. F. Perrin, B. Wursig and J. G. M. Thewissen. San Diego, CA, Academic Press**:** 1001-1003.

Horwood, J. (1987). *The Sei Whale: Population Biology, Ecology, and Management*. New York, NY, Croom Helm**:** 375.

Houser, D. S., J. J. Finneran, and S. H. Ridgway (2010b). Research with Navy Marine Mammals Benefits Animal Care, Conservation and Biology. International Journal of Comparative Psychology, 23, 249-268.

Hughes, G. R., P. Luschi, R. Mencacci, and F. Papi (1998). The 7000-km oceanic journey of a leatherback turtle tracked by satellite. Journal of Experimental Marine Biology and Ecology, 229, 209-217.

Hui, C. A. (1985). "Undersea topography and the comparative distribution of two pelagic cetaceans." Fishery Bulletin 83: 472-475.

James, M. C., T. B. Herman (2001). Feeding of Dermochelys coriacea on medusae in the northwest Atlantic. Chelonian Conservation and Biology, 4(1), 202-205.

James, M. C., and N. Mrosovsky (2004). Body temperatures of leatherback turtles (*Dermochelys coriacea*) in temperate waters off Nova Scotia, Canada. Canadian Journal of Zoology, 82, 1302-1306. doi: 10.1139/Z04-110.

James, M. C., S. A. Sherrill-Mix, K. Martin, and R. A. Myers (2006). Canadian waters provide critical foraging habitat for leatherback sea turtles. Biological Conservation, 133(3), 347-357.

James, M. C., R. A. Myers, and C. A. Ottensmeyer (2005a). Behaviour of leatherback sea turtles, *Dermochelys coriacea*, during the migratory cycle. Proceedings of the Royal Society B: Biological Sciences, 272, 1547-1555. doi: 10.1098/rspb.2005.3110.

James, M. C., C. A. Ottensmeyer, and R. A. Myers (2005b). Identification of high-use habitat and threats to leatherback sea turtles in northern waters: New directions for conservation. Ecology Letters, 2005(8), 195-201. doi: 10.1111/j.1461-0248.2004.00710.x.

Jefferson, T. A. (2009b). Rough-toothed dolphin Steno bredanensis. In W. F. Perrin, B. Wursig & J. G. M. Thewissen (Eds.), Encyclopedia of Marine Mammals (Second Edition) (pp. 990-992): Academic Press.

Jefferson, T. A., and N. B. Barros (1997). "Peponocephala electra." Mammalian Species 553: 1-6.

Jefferson, T. A., and S. Leatherwood (1994). "*Lagenodelphis hosei*." Mammalian Species 470: 1-5.

Jefferson, T. A., M. A. Webber, and R. L. Pitman (2015). *Marine Mammals of the World: A Comprehensive Guide to their Identification*. Second Edition. London, UK, Elsevier: 608 p.

Jepson, P., P. Bennett, R. Deaville, C. R. Allchin, J. Baker, and R. Law (2005). Relationships between polychlorinated Biphenyls and Health Status in Harbor Porpoises (Phocoena Phocoena) Stranded in the United Kingdom. Environmental Toxicology and Chemistry, 24(1), 238-248.

Jones, T. T. (2009). Energetics of the leatherback turtle (*Dermochelys coriacea*). Thesis.

Jonsen, I. D., R. A. Myers, and M. C. James (2007). Identifying leatherback turtle foraging behaviour from satellite telemetry using a switching state-space model. Marine Ecology Progress Series 337, 255-264.

Johanos, T. C., A. L. Harting, T. L. Wurth, and J. D. Baker (2015). Range-wide patterns in Hawaiian monk seal movements among islands and atolls. U.S. Department of Commerce, NOAA Technical Memorandum, NOAA-TM NMFS-PIFSC-44, 26 p. doi:10.7289/V5FT8J02.

Kalb, H., and D. Owens (1994). Differences between solitary and arribada nesting olive ridley females during the internesting period. In K. A. Bjorndal, A. B. Bolten, D. A. Johnson and P. J. Eliazar (Eds.), Proceedings of the Fourteenth Annual Symposium on Sea Turtle Biology and Conservation. (NOAA Technical Memorandum NMFS-SEFSC-351, pp. 68) U.S. Department of Commerce, National Oceanic and Atmospheric Administration and National Marine Fisheries Service.

Kamezaki, N., Y. Matsuzawa, O. Abe, H. Asakawa, T. Fujii, K. Goto, and I. Wakabayashi (2003). Loggerhead turtles nesting in Japan. In A. B. Bolten and B. E. Witherington (Eds.), Loggerhead Sea Turtles (pp. 210-217). Washington DC: Smithsonian Books.

Kanda, N., M. Goto, H. Kato, M. V. McPhee, and L. A. Pastene (2007). "Population genetic structure of Bryde's whales (Balaenoptera brydei) at the inter-oceanic and trans-equatorial levels." Conservative Genetics 8(4): 853-864.

Kato, H., and W. F. Perrin (2008). Bryde's whales *Balaenoptera edeni/brydei*. In: Encyclopedia of Marine Mammals. W. F. Perrin, B. Wursig and J. G. M. Thewissen. San Diego, CA, Academic Press**:** 158-163.

Katsumata, E., K. Ohishi, and T. Maruyama (2004). "Rehabilitation of a rescued pygmy sperm whale stranded on the Pacific coast of Japan." IEEE Journal: 488-491.

Keck, N., O. Kwiatek, F. Dhermain, F. Dupraz, H. Boulet, C. Danes, C. Laprie, A. Perrin, J. Godenir, L. Micout, and G. Libeau (2010). "Resurgence of Morbillivirus infection in Mediterranean dolphins off the French coast." The Veterinary record 166(21): 654-655.

Keevin, T. M., and G. L. Hempen (1997). *The Environmental Effects of Underwater Explosions with Methods to Mitigate Impacts*. U.S. Army Corps of Engineers, St. Louis District.

Keinath, J. A., and J. A. Musick (1993). Movements and diving behavior of a leatherback turtle, Dermochelys coriacea. Copeia, 1993(4), 1010-1017.

Kemp, N. J. (1996). Habitat loss and degradation. In The Conservation of Whales and Dolphins. M. P. Simmonds and J. Lagerquist, B. A., B. R. Mate, J. G. Ortega-Ortiz, M. Winsor, and J. Urban-Ramirez (2008). Migratory movements and surfacing rates of humpback whales (Megaptera novaeangliae) satellite tagged at Socorro Island, Mexico. Marine Mammal Science, 24(4): 815–830. D. Hutchinson. New York, NY, John Wiley & Sons**:** 476.

Kenney, R. D., and H. E. Winn (1987). "Cetacean biomass densities near submarine canyons compared to adjacent shelf/slope areas." Continental Shelf Research **7**: 107-114.

Kishiro, T. (1996). "Movements of marked Bryde's whales in the western North Pacific." Reports of the International Whaling Commission 46: 421-428.

Krahn, M. M., M. J. Ford, W. F. Perrin, P. R. Wade, R. P. Angliss, M. B. Hanson, B. L. Taylor, G. M. Ylitalo, M. E. Dahlheim, J. E. Stein, and R. S. Waples (2004). *2004 Status Review of Southern Resident Killer Whales (Orcinus orca) under the Endangered Species Act*. Seattle, WA, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northwest Fisheries Science Center**:** 73.

Kruse, S., D. K. Caldwell, and M. C. Caldwell (1999). Risso's dolphin *Grampus griseus* (G. Cuvier, 1812). In: Handbook of Marine Mammals. S. H. Ridgway and R. Harrison. San Diego, CA, Academic Press. 6**:**183-212.

Kuker, K. J., J. A. Thomson, and U. Tscherter (2005). "Novel surface feeding tactics of minke whales, Balaenoptera acutorostrata, in the Saguenay-St. Lawrence National Marine Park." Canadian Field-Naturalist 119(2): 214-218.

Laist, D. W. (1997). Impacts of marine debris: Entanglement of marine life in marine debris including a comprehensive list of species with entanglement and ingestion records. In J. M. Coe and D. B. Rogers (Eds.), *Marine Debris: Sources, Impacts, and Solutions* (pp. 99-140). New York, NY: Springer-Verlag.

Lammers, M. O. (2004). "Occurrence and behavior of Hawaiian spinner dolphins (*Stenella longirostris*) along Oahu's leeward and south shores." Aquatic Mammals 30(2): 237-250.

Lammers, M. O., P. I. Fisher-Pool, W. W. L. Au, C. G. Meyer, K. B. Wong, R. E. Brainard (2011). Humpback whale Megaptera novaeangliae song reveals wintering activity in the Northwestern Hawaiian Islands. Marine Ecology Progress Series, 423: 261–268.

Law, K. L., S. Moret-Ferguson, N. A. Maximenko, G. Proskurowski, E. E. Peacock, J. Hafner, and C. M. Reddy (2010). Plastic Accumulation in the North Atlantic Subtropical Gyre. *Science* 329, 1185 (2010). DOI: 10.1126/science.1192321.

Lazell, J. D., Jr. (1980). New England waters: Critical habitat for marine turtles. Copeia, 1980(2), 290-295.

Leatherwood, S., W. F. Perrin, V. L. Kirby, C. L. Hubbs, and M. Dahlheim (1980). "Distribution and movements of Risso's dolphin, *Grampus griseus*, in the eastern North Pacific." Fishery Bulletin 77(4): 951-963.

Lenhardt, M. L. (2002). "Sea turtle auditory behavior." *Journal of the Acoustical Society of America 112*(5, Part 2): 2314.

Lenhardt M. L. (1994). Seismic and very low frequency sound induced behaviors in captive loggerhead marine turtles (*Caretta caretta*), in: K. A. Bjorndal, et al. (Eds.), Fourteenth Annual Symposium on Sea Turtle Biology and Conservation, Hilton Head, South Carolina.

Lenhardt M. L., Klinger R. C., Musick J. A. (1985). Marine Turtle Middle-Ear Anatomy. The Journal of Auditory Research 25:66-72.

Lenhardt, M. L., S. Bellmund, R. A. Byles, S. W. Harkins, and J. A. Musick (1983). Marine turtle reception of bone-conducted sound. *Journal of Auditory Research 23*: 119-125.

Leslie, M. S., A. Batibasaga, D. S. Weber, D. Olson, and H. C. Rosenbaum (2005). "First record of Blainville's beaked whale *Mesoplodon densirostris* in Fiji." Pacific Conservation Biology 11(4): 302-304.

Lewis, J. A. (1996). *Effects of Underwater Explosions on Life in the Sea*. Department of Defence (Australia), Defence and Science Technology Organisation. August 1996.

Limpus, C. J. (1992). The hawksbill turtle, *Eretmochelys imbricata*, in Queensland: population structure within a southern Great Barrier Reef ground. Wildlife Research 19, 489-506.

Lindstrom, U., and T. Haug (2001). "Feeding strategy and prey selectivity in common minke whales (*Balaenoptera acutorostrata*) foraging in the southern Barents Sea during early summer." Journal of Cetacean Research and Management 3(3): 239-250.

Littnan, C. (2011). *Habitat Use and Behavioral Monitoring of Hawaiian Monk Seals in Proximity to the Navy Hawaii Range Complex. Report Period: August 2010-July 2011.* Appendix M, HRC annual monitoring report for 2011, submitted to National Marine Fisheries Service.

Littnan, C. (2012). *Habitat Use and Behavioral Monitoring of Hawaiian Monk Seals in Proximity to the Navy Hawaii Range Complex*. Report Period: July 2011-June 2012.

Littnan, C. L., B. S. Stewart, P. K. Yochem, and R. Braun (2007). "Survey of selected pathogens and evaluation of disease risk factors for endangered Hawaiian monk seals in the main Hawaiian Islands." EcoHealth 3: 232–244.

Lodi, L., and B. Hetzel (1999). "Rough-toothed dolphin, Steno bredanensis, feeding behaviors in Ilha Grande Bay, Brazil." Biociências 7(1): 29-42.

Lohmann, K. J., and C. M. F. Lohmann (1996). Detection of magnetic field intensity by sea turtles. Nature, 380, 59-61. doi:10.1038/380059a0.

Lohmann, K. J., and C. M. F. Lohmann (1992). Orientation to oceanic waves by green sea turtle hatchlings. Journal of Experimental Biology, 171, 1-13.

Lohmann, K. J., B. E. Witherington, C. M. F. Lohmann, and M. Salmon (1997). Orientation, navigation, and natal beach homing in sea turtles. In P. L. Lutz and J. A. Musick (Eds.), The Biology of Sea Turtles (pp. 107-136). Boca Raton, FL: CRC Press.

Lusseau, D., and L. Bejder (2007). The Long-term Consequences of Short-term Responses to Disturbance Experiences from Whalewatching Impact Assessment. International Journal of Comparative Psychology, 20(2), 228-236. Retrieved from http://escholarship.org/uc/item/42m224qc.

Lusseau, D., D. E. Bain, R. Williams, and J. C. Smith (2009). "Vessel traffic disrupts the foraging behavior of southern resident killer whales *Orcinus orca*." Endangered Species Research 6: 211–221.

Lutcavage, M. E., and P. L. Lutz (1997). Diving Physiology. In P. L. Lutz and J. A. Musick (Eds.), The Biology of Sea Turtles (pp. 277-296). Boca Raton, FL: CRC Press.

MacLeod, C. D., and A. D'Amico (2006). "A review of beaked whale behaviour and ecology in relation to assessing and mitigating impacts of anthropogenic noise." Journal of Cetacean Research and Management **7**(3): 211-222.

MacLeod, C. D., and G. Mitchell (2006). "Key areas for beaked whales worldwide." Journal of Cetacean Research and Management 7(3): 309-322.

MacLeod, C. D., N. Hauser, and H. Peckham (2006a). "Known and inferred distributions of beaked whale species (Ziphiidae: Cetacea)." Journal of Cetacean Research and Management 7(3): 271-286.Macleod, C.D., Simmonds, M.P., and E. Murry (2006b). Abundance of fin (*Balaenoptera physalus*) and sei whales (B**.**

borealis) amid oil exploration and development off northwest Scotland. Journal of Cetacean Research and Management (3) Vol. 8, pp. 247-254.

MacLeod, C. D., N. Hauser, and H. Peckham (2006a). "Known and inferred distributions of beaked whale species (Ziphiidae: Cetacea)." Journal of Cetacean Research and Management 7(3): 271-286.Macleod, C.D., Simmonds, M.P., and E. Murry (2006b). Abundance of fin (*Balaenoptera physalus*) and sei whales (B. *borealis*) amid oil exploration and development off northwest Scotland. Journal of Cetacean Research and Management (3) Vol. 8, pp. 247-254.

Macleod, C.D., M.P. Simmonds, and E. Murry (2006b). Abundance of fin (*Balaenoptera physalus*) and sei whales (B. *borealis*) amid oil exploration and development off northwest Scotland. Journal of Cetacean Research and Management (3) Vol. 8, pp. 247-254.

MacLeod, C. D., N. Hauser, and H. Peckham (2004). "Diversity, relative density and structure of the cetacean community in summer months east of Great Abaco, Bahamas." Journal of the Marine Biological Association of the United Kingdom 84: 469-474.

MacLeod, C. D., N. Hauser, and H. Peckham (2003). "Review of data on diets of beaked whales: evidence of niche separation and geographic segregation." Journal of the Marine Biological Association of the United Kingdom 83: 651-665.

Maison, K. A., I. K. Kelly, and K. P. Frutchey (2010). Green sea turtle Nesting Sites and Sea Turtle Legislation throughout Oceania. (NOAA Technical Memorandum NMFS-F/SPO- 110, pp. 56) U.S. Department of Commerce, National Oceanic and Atmospheric Administration, and National Marine Fisheries Service.

Makowski, C., J. A. Seminoff, and M. Salmon (2006). Home range and habitat use of juvenile Atlantic green sea turtles (*Chelonia mydas L.*) on shallow reef habitats in Palm Beach, Florida, USA. Marine Biology, 148, 1167-1179. doi: 10.1007/s00227-005-0150-y.

Maldini Feinholz, D. (2003). Abundance and distribution patterns of Hawaiian odontocetes: Focus on O'ahu. Ph. D. Ph.D. dissertation, University of Hawaii.

Maldini, D., L. Mazzuca, and S. Atkinson (2005). "Odontocete stranding patterns in the main Hawaiian Islands (1937-2002): How do they compare with live animal surveys?" Pacific Science 59(1): 55-67.

Marcoux, M., H. Whitehead, and L. Rendell (2007). "Sperm whale feeding variations by location, year, social group and clan: Evidence from stable isotopes." Marine Ecology Progress Series 333: 309-314.

Marine Mammal Commission (2003). *Workshop on the management of Hawaiian monk seals on beaches in the main Hawaiian Islands***:** 5.

Marine Mammal Commission (2002). Hawaiian monk seal (*Monachus schauinslandi*). Species of Special Concern, Annual Report to Congress, 2001. Bethesda, MD, Marine Mammal Commission**:** 63-76.

Marini, L., C. Consiglio, B. Catalano, and T. Valentini (1996). Aerial behavior in fin whales (*Balaenoptera physalus*) in the Mediterranean Sea. Marine Mammal Science 12(3):489-495. July.

Márquez M., R. (1990). FAO Species Catalogue: SeaTurtles of the World. An Annotated and Illustrated Catalogue of Sea Turtle Species known to date. (Vol. 11, FAO Fisheries Synopsis. No. 125, pp. 81). Rome, Italy: Food and Agriculture Organization of the United Nations.

Marsh, H. E. (1989). "Mass Stranding of Dugongs by a Tropical Cyclone in Northern Australia." Marine Mammal Science 5(1): 78-84.

Marten, K. (2000). "Ultrasonic analysis of pygmy sperm whale (*Kogia breviceps*) and Hubbs' beaked whale (*Mesoplodon carlhubbsi*) clicks." Aquatic Mammals 26(1): 45-48.

Marten, K., and S. Psarakos (1999). "Long-term site fidelity and possible long-term associations of wild spinner dolphins (*Stenella longirostris*) seen off Oahu, Hawaii." Marine Mammal Science 15(4): 1329-1336.

Martin, S. W., C. R. Martin, B. M. Matsuyama, and E. E. Henderson (2015). Minke whales (*Balaenoptera acutorostrata*) respond to navy training. Journal of the Acoustical Society of America 137(5), May 2015.

Martin, C. R., S. W. Martin, E. E. Henderson, T. A. Helble, R. A. Manzano-Roth, and B. M. Matsuyama (2016). SSC Pacific FY15 annual report on PMRF Marine Mammal Monitoring.

Masaki, Y. (1976). "Biological studies on the North Pacific sei whale." Bulletin of the Far Seas Fisheries Research Laboratory 14: 1-104.

Masaki, Y. (1977). "The separation of the stock units of sei whales in the North Pacific." Reports of the International Whaling Commission (Special Issue 1): 71-79.

Mate, B. R., R. Gisiner, and J. Mobeley (1998). Local and migratory movements of Hawaiian humpback whales tracked by satellite telemetry. Canadian Journal of Zoology, Vol 76, 1998.

Matkin, C. O., E. L. Saulitis, G. M. Ellis, P. Olesiuk, and S. D. Rice (2008). Ongoing population-level impacts on killer whales Orcinus orca following the 'Exxon Valdez' oil spill in Prince William Sound, Alaska. Marine Ecology Progress Series, 356, 269-281. doi: 10.3354/meps07273.

McAlpine, D. F. (2009). Pygmy and dwarf sperm whales *Kogia breviceps* and ***K. sima.*** In: Encyclopedia of Marine Mammals (Second Edition). W. F. Perrin, B. Wursig and J. G. M. Thewissen, Academic Press**:** 936-938.

McCauley, R. D., J. Fewtrell, A. J. Duncan, C. Jenner, M.-N. Jenner, J. D. Penrose, R. I. T. Prince, A. Adhitya, J. Murdoch, K. A. McCabe (2000). Marine Seismic Surveys: Analysis and Propagation of Air-gun Signals; and Effects of Air-gun Exposure on Humpback Whales, Sea Turtles, Fishes and Squid, Centre for Marine Science and Technology, Western Australia. pp. 198.

McClellan, C. M., and A. J. Read (2007). Complexity and variation in loggerhead sea turtle life history. Biology Letters 3, 592-594. doi: 10.1098/rsbl.2007.0355.

McCracken, M. L. (2000). Estimation of Sea Turtle Take and Mortality in the Hawaiian Longline Fisheries. (SWFSC Administrative Report H-00-06, pp. 29). Honolulu, HI: Southwest Fisheries Science Center.

McCracken, M. L., and K. A Forney (2010). Preliminary Assessment of Incidental Interactions with Marine Mammals in the Hawaii Longline Deep and Shallow Set Fisheries. National Marine Fisheries Service, PIFSC Working Paper WP-10-001.

McDonald, M., J. Hildebrand, S. Wiggins, and D. Ross (2008). "A 50 Year comparison of ambient ocean noise near San Clemente Island: A bathymetrically complex coastal region off Southern California." Journal of the Acoustical Society of America: 1985-1992.

McSweeney, D. J., R. W. Baird, and S. D. Mahaffy (2007). "Site fidelity, associations, and movements of Cuvier's (*Ziphius cavirostris*) and Blainville's (*Mesoplodon densirostris*) beaked whales off the Island of Hawaii." Marine Mammal Science 23(3): 666-687.

McVey, J. P., and T. Wibbels (1984). The growth and movements of captive-reared Kemp's ridley sea turtles, *Lepidochelys kempii*, following their release in the Gulf of Mexico. NOAA Technical Memorandum NMFS-SEFC-145, 25p.

Mead, J. G. (1989). Beaked whales of the genus *Mesoplodon.* In: Handbook of Marine Mammals. S. H. Ridgway and R. Harrison. San Diego, CA, Academic Press. 4: 349-430.

Mead, J. G., and C. W. Potter (1995). "Recognizing two populations of the bottlenose dolphin (*Tursiops truncatus*) off the Atlantic Coast of North America: Morphologic and ecologic considerations." IBI Reports 5: 31-44.

Meylan, A. B. (1999). International movements of immature and adult hawksbill turtles (*Eretmochelys imbricata*) in the Caribbean region. Chelonian Conservation and Biology, 3(2), 189-194.

Meylan, A. (1995). Sea turtle migration evidence from tag returns. In K. A. Bjorndal (Ed.), Biology and Conservation of Sea Turtles (Revised ed., pp. 91-100). Washington, DC: Smithsonian Institution Press.

Meylan, A. B. (1988). Spongivory in hawksbill turtles: A diet of glass. Science, 239, 393-395.

Meylan, A. B., and M. Donnelly (1999). Status justification for listing the hawksbill turtle (*Eretmochelys imbricata*) as critically endangered on the 1996 IUCN Red List of Threatened Animals. Chelonian Conservation and Biology, 3(2), 200-224.

Mignucci-Giannoni, A. A. (1998). "Zoogeography of cetaceans off Puerto Rico and the Virgin Islands." Caribbean Journal of Science 34(3-4): 173-190.

Miller, J. D., C. J. Limpus, and M. H. Godfrey (2003). Nest site selection, oviposition, eggs, development, hatching, and emergence of loggerhead turtles. In A. B. Bolten and B. E. Witherington (Eds.), Loggerhead Sea Turtles (pp. 125-143). Washington, DC: Smithsonian Institution Press.

Miyashita, T. (1993). "Distribution and abundance of some dolphins taken in the North Pacific driftnet fisheries." International North Pacific Fisheries Commission Bulletin 53(3): 435-450.

Miyashita, T., T. Kishiro, N. Higashi, F. Sato, K. Mori, and H. Kato (1996). "Winter distribution of cetaceans in the western North Pacific inferred from sighting cruises 1993-1995." Reports of the International Whaling Commission 46: 437-442.

Miyazaki, N., and W. F. Perrin (1994). Rough-toothed dolphin *Steno bredanensis* (Lesson, 1828). In Handbook of Marine Mammals. S. H. Ridgway and R. Harrison. San Diego, CA, Academic Press. 5: 1-21.

Miyazaki, N., and S. Wada (1978). "Fraser's dolphin, *Lagenodelphis hosei* in the western North Pacific." Scientific Reports of the Whales Research Institute 30: 231-244.

Mizroch, S. A., D. W. Rice, D. Zwiefelhofer, J. Waite, and W. L. Perryman (2009). "Distribution and movements of fin whales in the North Pacific Ocean." Mammal Review 39: 193-227.

Mobley, J. R. (2004). *Results of Marine Mammal Surveys on U.S. Navy Underwater Ranges in Hawaii and Bahamas*: 27.

Mobley, J. R. (2005). "Assessing responses of humpback whales to North Pacific Acoustic Laboratory (NPAL) transmissions: Results of 2001-2003 aerial surveys north of Kauai." Journal of the Acoustical Society of America 117: 1666-1773.

Mobley, J. R., Jr., L. Mazzuca, A. S. Craig, M. W. Newcomer, and S. S. Spitz (2001a). "Killer whales (*Orcinus orca*) sighted west of Ni'ihau, Hawai'i." Pacific Science 55: 301-303.

Mobley, J., S. Spitz, and R. Grotefendt (2001b). Abundance of Humpback Whales in Hawaiian Waters: Results of 1993-2000 Aerial Surveys, Hawaiian Islands Humpback Whale National Marine Sanctuary, Department of Land and Natural Resources, State of Hawaii: 17.

Mobley, J. R., Jr., S. S. Spitz, K. A. Forney, R. Grotefendt, and P. H. Forestell (2000). *Distribution and Abundance of Odontocete Species in Hawaiian Waters: Preliminary Results of 1993-98 Aerial Surveys*, Southwest Fisheries Science Center**:** 26.

Mobley, J. R., Jr., G. B. Bauer, and L. M. Herman (1999). “Changes over a ten-year interval in the distribution and relative abundance of humpback whales (*Megaptera novaeangliae*) wintering in Hawaiian waters.” Aquatic Mammals 25: 63-72.

Mobley, J. R., Jr., M. Smultea, T. Norris, and D. Weller (1996). “Fin whale sighting north of Kaua’i, Hawai’i.” Pacific Science 50: 230-233.

Moein Bartol, S.E., J. A. Musick, J. A. Keinath, D. E. Barnard, M. L. Lenhardt, and R. George (1995). Evaluation of Seismic Sources for Repelling Sea Turtles from Hopper Dredges, in: L. Z. Hales (Ed.), Sea Turtle Research Program: Summary Report, U.S. Army Engineer Division, South Atlantic, Atlanta, Georgia and U.S. Naval Submarine Base, Kings Bay, Georgia. pp. 90-93.

Moon, H. B., K. Kannan, M. Choi, J. Yu, H. G. Choi, Y. R. An, Z. G. Kim (2010). Chlorinated and brominated contaminants including PCBs and PBDEs in minke whales and common dolphins from Korean coastal waters. Journal of Hazardous Materials, 179(1-3), 735-741.

Moore, J. C. (1972). “More skull characters of the beaked whale *Indopacetus pacificus* and comparative measurements of austral relatives.” Fieldiana Zoology 62: 1-19.

Moretti, D., T. A. Marques, L. Thomas, N. DiMarzio, A. Dilley, R. Morrissey, E. McCarthy, J. Ward, and S. Jarvis (2010). A dive counting density estimation method for Blainville’s beaked whale (Mesoplodon densirostris) using a bottom-mounted hydrophone field as applied to a Mid-Frequency Active (MFA) sonar operation. Applied Acoustics 71:1036-1042.

Morreale, S. J., E. A. Standora, J. R. Spotila, and F. V. Paladino (1996). Migration corridor for sea turtles. Nature, 384, 319-320.

Mortimer, J. A. (1995). Feeding ecology of sea turtles. In K. A. Bjorndal (Ed.), Biology and Conservation of Sea Turtles (Revised ed., pp. 103-109). Washington, DC: Smithsonian Institution Press.

Mortimer, J. A., and R. Bresson (1999). Temporal distribution and periodicity in hawksbill turtles (*Eretmochelys imbricata*) nesting at Cousin Island, Republic of Seychelles, 1971-1997. Chelonian Conservation and Biology, 3(2), 318-325.

Mortimer, J. A., and M. Donnelly (2008). Hawksbill Turtle (*Eretmochelys imbricata*): Marine Turtle Specialist Group 2008 IUCN Red List status assessment. [Web Page]. Retrieved from www.iucnredlist.org, 03 September 2009.

Mrosovsky, N. (1980). Thermal biology of sea turtles. American Zoologist, 20(3), 531-547.

Mrosovsky, N., and P. C. H. Pritchard (1971). Body temperatures of Dermochelys coriacea and other sea turtles. Copeia, 1971(4), 624-631.

Mrosovsky, N., G. D. Ryan, and M. C. James (2009). Leatherback turtles: The menace of plastic. Marine Pollution Bulletin, 58, 287-289.

Musick, J. A., and C. J. Limpus (1997). Habitat utilization and migration of juvenile sea turtles. In P. L. Lutz and J. A. Musick (Eds.), The Biology of Sea Turtles (pp. 137-163). Boca Raton, FL: CRC Press.

Mussi, B., A. Miragliuolo, T. De Pippo, M. C. Gambi, and D. Chiota (2004). “The submarine canyon of Cuma (southern Tyrrhenian Sea, Italy), a cetacean key area to protect.” European Research on Cetaceans 15: 178-179.

Myers, A. E., and G. C. Hays (2006). Do leatherback turtles *Dermochelys coriacea* forage during the breeding season? A combination of data-logging devices provide new insights. Marine Ecology Progress Series, 322, 259-267.

Nachtigall, P. E., A. Y. Supin, J. Pawloski, and W. W. L. Au (2004). Temporary Threshold Shifts after Noise Exposure in the Bottlenose Dolphin (*Tursiops truncatus*) Measured Using Evoked Auditory Potentials. Marine Mammal Science 20:673–687.

Nachtigall P. E., J. L. Pawloski, W. W. L. Au (2003). Temporary Threshold Shifts and Recovery Following Noise Exposure in the Atlantic Bottlenosed Dolphin (*Tursiops truncatus*). Journal of the Acoustical Society of America 113:3425-3429.

National Cooperative Highway Research Program (NCHRP) (2011). Hyroacoustic Impacts on Fish from Pile Installation. October 2011.

National Marine Fisheries Service (2016). Species in the Spotlight. Priority Actions: 2016-2020. Hawaiian Monk Seal 5-Year Action Plan.

National Marine Fisheries Service (2014). Final Programmatic Environmental Impact Statement for Hawaiian Monk Seal Recovery Actions. March 2014.

National Marine Fisheries Service (2012). Endangered and Threatened Wildlife and Plants; Endangered Status for the Main Hawaiian Islands Insular False Killer Whale Distinct Population Segment. Federal Register, 77(229), 70915-70939.

National Marine Fisheries Service (2011). Hawaii Longline Deep Set Quarterly and Annual Status Reports, 2004 2011. Retrieved from: http://www.fpir.noaa.gov/OBS/obs_hi_ll_ds_rprts.html.

National Marine Fisheries Service (2011c). Pacific Science Center Stranding Data. Excel file containing stranding from the Hawaiian Islands, manuscript on file.

National Marine Fisheries Service (2011d). Pacific Islands Region, Marine Mammal Response Network Activity Update #17.

National Marine Fisheries Service (2010b). Pacific Islands Regional Office. Hawaiian monk seal population and location. 2010.

National Marine Fisheries Service (2010b). Marine Turtles. [Web Page] NOAA Fisheries Office of Protected Resources. Retrieved from http://www.nmfs.noaa.gov/pr/species/turtles/, 25 May 2010.

National Marine Fisheries Service (2010c). Pacific Islands Regional Office. Hawaiian monk seal top threats. 2010.

National Marine Fisheries Service (2010e). Pacific Islands Region, Marine Mammal Response Network Activity Update #14 (pp. 6).

National Marine Fisheries Service (2009a). Taking and Importing of Marine Mammals; U.S. Navy Training in the Hawaii Range Complex; Final Rule. Federal Register, Monday, January 12, 2009, 74(7):1456-1491.

National Marine Fisheries Service (2008a). Pacific Islands Region, Marine Mammal Response Network Activity Update #8.

National Marine Fisheries Service (2007a). Pacific Islands Region, Marine Mammal Response Network Activity Update #5.

National Marine Fisheries Service (2007d). Recovery plan for the Hawaiian monk seal (*Monachus schauinslandi*). Silver Spring, MD, National Marine Fisheries Service**:** 165.

National Marine Fisheries Service, Pacific Islands Fisheries Science Center (2004). Cause of Stranding Database for Marine Turtle Strandings in the Hawaiian Islands, 1982-2003. (Vol. 154). Honolulu, HI: National Marine Fisheries Service Pacific Islands Fisheries Science Center.

National Marine Fisheries Service, Southeast Fisheries Science Center (2001). Stock Assessments of Loggerhead and Leatherback Sea Turtles and an Assessment of the Impact of the Pelagic Longline Fishery on the Loggerhead and Leatherback Sea Turtles of the Western North Atlantic. (NOAA Technical Memorandum NMFS-SEFSC-455, pp. 343) U.S. Department of Commerce.

National Marine Fisheries Service (1988). “Critical habitat; Hawaiian monk seal; Endangered Species Act.” Federal Register 53(102): 18988-18998.

National Marine Fisheries Service (1986). “Designated critical habitat; Hawaiian monk seal.” Federal Register 51(83): 16047-16053.

National Marine Fisheries Service and U.S. Fish and Wildlife Service (2007a). Green Sea Turtle (*Chelonia mydas*) 5-year Review: Summary and Evaluation. (pp. 102). Silver Spring, MD: National Marine Fisheries Service.

National Marine Fisheries Service and U.S. Fish and Wildlife Service (2007b). Hawksbill Sea Turtle (*Eretmochelys imbricata*) 5-year Review: Summary and Evaluation. (pp. 90). Silver Spring, MD: National Marine Fisheries Service.

National Marine Fisheries Service and U.S. Fish and Wildlife Service (2007c). Leatherback Sea Turtle (*Dermochelys coriacea*) 5-year Review: Summary and Evaluation. (pp. 79). Silver Spring, MD: National Marine Fisheries.

National Marine Fisheries Service and U.S. Fish and Wildlife Service (2007d). Loggerhead Sea Turtle (*Caretta caretta*) 5-year Review: Summary and Evaluation. (pp. 65). Silver Spring, MD: National Marine Fisheries Service.

National Marine Fisheries Service and U.S. Fish and Wildlife Service (2007e). Olive Ridley Sea Turtle (*Lepidochelys olivacea*) 5-year Review: Summary and Evaluation. (pp. 64). Silver Spring, MD: National Marine Fisheries Service.

National Marine Fisheries Service and U.S. Fish and Wildlife Service (1998b). Recovery Plan for U.S. Pacific Populations of the Green sea turtle (*Chelonia mydas*). (pp. 84). Silver Spring, MD: National Marine Fisheries Service.

National Marine Fisheries Service and U.S. Fish and Wildlife Service (1998c). Recovery Plan for U.S. Pacific Populations of the Hawksbill Turtle (*Eretmochelys imbricata*). (pp. 83). Silver Spring, MD: National Marine Fisheries Service.

National Marine Fisheries Service and U.S. Fish and Wildlife Service (1998d). Recovery Plan for U.S. Pacific Populations of the Leatherback Turtle (Dermochelys coriacea). (pp. 65). Silver Spring, MD: National Marine Fisheries Service.

National Marine Fisheries Service and U.S. Fish and Wildlife Service (1998e). Recovery Plan for U.S. Pacific Populations of the Loggerhead Turtle (*Caretta caretta*). (pp. 59). Silver Spring, MD: National Marine Fisheries Service.

National Marine Fisheries Service and U.S. Fish and Wildlife Service (1998f). Recovery Plan for U.S. Pacific Populations of the Olive Ridley Turtle (*Lepidochelys olivacea*). (pp. 52). Silver Spring, MD: National Marine Fisheries Service.

National Marine Fisheries Service and U.S. Fish and Wildlife Service (1992). Recovery Plan for Leatherback Turtles *Dermochelys coriacea* in the U.S. Carribean, Atlantic and Gulf of Mexico (pp. 65). Silver Spring, MD: National Marine Fisheries Service.

National Marine Fisheries Service and U.S. Fish and Wildlife Service (1991). Recovery Plan for U.S. Populations of Atlantic Green sea turtle *Chelonia mydas*. (pp. 52). Washington, DC: National Marine Fisheries Service.

National Oceanographic and Atmospheric Administration (NOAA) (2015). Draft Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing: Underwater Acoustic Threshold Levels for Onset of Permanent and Temporary Threshold Shifts. Revised Version for Second Public Comment Period. July 23, 2015.

National Oceanic and Atmospheric Administration (2012). Endangered and Threatened Wildlife and Plants; Endangered Status for the Main Hawaiian Islands Insular False Killer Whale Distinct Population Segment. Federal Register, 77(229), 70915-70939.

National Oceanic and Atmospheric Administration (1996). Magnuson Act provisions; Consolidation and update of regulations. [Proposed rule; request for comments]. Federal Register, 61(85), 19390-19429.

National Oceanic and Atmospheric Administration (NOAA) Fisheries (2015). Hawaiian Monk Seal (*Neomonachus schauinslandi*). Information last updated on August 21, 2015, and accessed at http://www.fisheries.noaa.gov/pr/species/mammals/seals/hawaiian-monk-seal.html. Information accessed on January 26, 2016.

National Research Council (2010). Assessment of Sea-Turtle Status and Trends: Integrating Demography and Abundance. Committee on the Review of Sea-Turtle Population Assessment Methods Ocean Studies Board Division on Earth and Life Studies. The National Academies Press. Washington, D.C.

National Research Council (2003). Ocean Noise and Marine Mammals (pp. 219). Washington, DC: National Academies Press.

National Research Council (2005). Marine Mammal Populations and Ocean Noise: Determining when Noise Causes Biologically Significant Effects. National Academies Press, Washington, DC.

Natoli, A., V. M. Peddemors, and A. R. Hoelzel (2004). "Population structure and speciation in the genus Tursiops based on microsatellite and mitochondrial DNA analyses." Journal of Evolutionary Biology 17: 363-375.

Naval Surface Warfare Center (1975). A Chemical Monitoring Program of the Explosion Products in Underwater Explosion Tests. NSWC Technical Report NSWC/WOL/TR. Naval Surface Weapons Center, White Oak Laboratory, Silver Spring, MD. 4 April 1975.

Neill, W. H., and E. D. Stevens (1974). Thermal inertia versus thermoregulation in "warm" turtles and tunas. Science, 184, 1008-1010.

Nemoto, T., and A. Kawamura (1977). "Characteristics of food habits and distribution of baleen whales with special reference to the abundance of North Pacific sei and Bryde's whales." Reports of the International Whaling Commission Special Issue 1: 80-87.

Norman, S. A., C. E. Bowlby, M. S. Brancato, J. Calambokidis, D. Duffield, P. J. Gearin, T. A. Gornall, M. E. Gosho, B. Hanson, J. Hodder, S. J. Jeffries, B. Lagerquist, D. M. Lambourn, B. Mate, B. Norberg, R. W.

Osborne, J. A. Rash, S. Riemer, and J. Scordino (2004). "Cetacean strandings in Oregon and Washington between 1930 and 2002." Journal of Cetacean Research and Management 6(1): 87-99.

Norris, K. S., and T. P. Dohl (1980). "Behavior of the Hawaiian spinner dolphin, Stenella longirostris." Fishery Bulletin 77: 821-849.

Norris, T. F., M. A. Smultea, A. M. Zoidis, S. Rankin, C. Loftus, C. Oedekoven, J. L. Hayes, and E. Silva (2005). *A Preliminary Acoustic-Visual Survey of Cetaceans in Deep Waters around Ni'ihau, Kaua'i, and portions of O'ahu, Hawai'i from Aboard the R/V* Dariabar. Bar Harbor, ME**:** 75.

Norris, T. F., M. McDonald, and J. Barlow (1999). "Acoustic detections of singing humpback whales (*Megaptera novaeangliae*) in the eastern North Pacific during their northbound migration." Journal of the Acoustical Society of America 106(1): 506-514.

Norris, K. S., B. Wursig, R. S. Wells, and M. Wursig (1994). *The Hawaiian Spinner Dolphin*. Berkeley, CA, University of California Press**:** 408.

Northridge, S. (2008). Fishing industry, effects of. In Encyclopedia of Marine Mammals. W. F. Perrin, B. Wursig and J. G. M. Thewissen. San Diego, CA, Academic Press: 443-447.

Nowacek, D., L. H. Thorne, D. Johnston, and P. Tyack (2007). "Responses of cetaceans to anthropogenic noise." Mammal Review 37(2): 81-115.

Odell, D. K., and K. M. McClune (1999). False killer whale -- *Pseudorca crassidens* (Owen, 1846). In: Handbook of Marine Mammals, vol. 6: The Second Book of Dolphins and the Porpoises. S. H. Ridgway and S. R. Harrison. New York, Academic Press. 6: The second book of dolphins and the porpoises: 213-244.

O'Hara, J., and J. R. Wilcox (1990). Avoidance responses of loggerhead turtles, *Caretta caretta*, to low frequency sound. Copeia 2:564-567.

Ohizumi, H., and T. Kishiro (2003). "Stomach contents of a Cuvier's beaked whale (*Ziphius cavirostris*) stranded on the central Pacific coast of Japan." Aquatic Mammals 29(1): 99-103.

Ohizumi, H., T. Matsuishi, and H. Kishino (2002). "Winter sightings of humpback and Bryde's whales in tropical waters of the western and central North Pacific." Aquatic Mammals 28(1): 73-77.

O'Keefe, D. J., and G. A. Young (1984). *Handbook on the Environmental Effects of Underwater Explosions*. Naval Surface Weapons Center, Dahlgren, Virginia. September 13.

Okuyama, J., S. Tomohito, O. Abe, K. Yoseda, and N. Arai (2010). Wild versus head-started hawksbill turtles *Eretmochelys imbricata*: post-release behavior and feeding adaptions. Endangered Species Research, January 2010.

Oleson, E., and M. Hill (2009). *Report to PACFLT: Data Collection and Preliminary Results from the Main Hawaiian Islands Cetacean Assessment Survey & Cetacean Monitoring Associated with Explosives Training off Oahu. 2010 Annual Range Complex Monitoring Report for Hawaii and Southern California.*

Oleson, E. M., C. H. Boggs, K. A. Forney, B. Hanson, D. R. Kobayashi, B. L. Taylor, P. Wade, and G. M. Ylitalo (2010). *Status Review of Hawaiian Insular False Killer Whales (*Pseudorca crassidens*) under the Endangered Species Act*, U.S. Department of Commerce and National Oceanic and Atmospheric Administration**:** 140 + Appendices.

Olson, P. A. (2009). Pilot whales *Globicephala melas* and *G. macrorhynchus*. In Encyclopedia of Marine Mammals. W. F. Perrin, B. Würsig and J. G. M. Thewissen. San Diego, CA, Academic Press**:** 898-903.

O'Malley, A. E. (2010). The Navy's Nature Guy. Midweek Kaua'i. Retrieved from http://www.midweekkauai.com/2010/09/the-navys-nature-guy.

Östman-Lind, J., A. D. Driscoll-Lind, and S. H. Rickards (2004). *Delphinid Abundance, Distribution and Habitat Use off the Western Coast of the Island of Hawaii*. La Jolla, CA, National Marine Fisheries Service.

Oswald, J. N., J. Barlow, and T. F. Norris (2003). "Acoustic identification of nine delphinid species in the eastern tropical Pacific Ocean." Marine Mammal Science 19(1): 20-37.

Paladino, F. V., M. P. O'Connor, and J. R. Spotila (1990). Metabolism of leatherback turtles, gigantothermy and thermoregulation of dinosaurs. Nature, 344, 858-860.

Panigada, S., M. Zanardelli, M. Mackenzie, C. Donovan, F. Melin, and P. Hammond (2008). "Modelling habitat preferences for fin whales and striped dolphins in the Pelagos Sanctuary (Western Mediterranean Sea) with physiographic and remote sensing variables." Remote Sensing of Environment 112(8): 3400-3412.

Paniz-Mondolfi, A. E., and L. Sander-Hoffmann (2009). "Lobomycosis in inshore and estuarine dolphins." Emerging Infectious Diseases 15(4): 672-673.

Parker, L. G. (1995). Encounter with a juvenile hawksbill turtle offshore Sapelo Island, Georgia. Marine Turtle Newsletter, 71, 19-22. Retrieved from http://www.seaturtle.org/mtn/archives/mtn71/mtn71p19.shtml.

Parker, D. M., and G. H. Balazs (2005). Diet of the oceanic green sea turtle, *Chelonia mydas*, in the north Pacific. In H. Kalb, A. S. Rohde, K. Gayheart and K. Shanker (Eds.), Proceedings of the Twenty- fifth Annual Symposioum on Sea Turtle Biology and Conservation [Abstract]. (NOAA Technical Memorandum NMFS-SEFSC-582, pp. 94) U.S. Department of Commerce, National Oceanic and Atmospheric Administration and National Marine Fisheries Service.

Parker, D. M., G. H. Balazs, C. S. King, L. Katahira, and W. Gilmartin (2009). Short-range movements of Hawksbill turtles (*Eretmochelys imbricata*) from nesting to foraging areas within the Hawaiian Islands. Pacific Science, 63(3), 371-382.

Parker, D. M., P. H. Dutton, K. Kopitsky, and R. L. Pitman (2003). Movement and dive behavior determined by satellite telemetry for male and female olive ridley turtles in the Eastern Tropical Pacific. In J. A. Seminoff (Ed.), Proceedings of the Twenty-Second Annual Symposium on Sea Turtle Biology and Conservation [Abstract]. (NOAA Technical Memorandum NMFS-SEFSC-503, pp. 48-49). U.S. Department of Commerce, National Oceanic and Atmospheric Administration and National Marine Fisheries Service. Available from http://www.nmfs.noaa.gov/pr/species/turtles/symposia.htm.

Parrish, F. A., G. J. Marshall, B. Buhleier, and G. A. Antonelis (2008). "Foraging interaction between monk seals and large predatory fish in the Northwestern Hawaiian Islands." Endangered Species Research 4(3): 299-308.

Parrish, F. A., M. P. Craig, T. J. Ragen, G. J. Marshall, and B. M. Buhleier (2000). "Identifying diurnal foraging habitat of endangered Hawaiian monk seals using a seal-mounted video camera." Marine Mammal Science 16(2): 392-412.

Payne, P. M., and D. W. Heinemann (1993). "The distribution of pilot whales (*Globicephala* spp.) in shelf/shelf edge and slope waters of the northeastern United States, 1978-1988." Reports of the International Whaling Commission Special Issue 14: 51-68.

Pelletier, D., D. Roos, and S. Ciccione (2003). Oceanic survival and movements of wild and captive-reared immature green sea turtles (*Chelonia mydas*) in the Indian Ocean. Aquatic Living Resources, 16, 35-41. doi: 10.1016/S0990-7440(03)00005-6.

Pennington, J. C., T. F. Jenkins, G. Ampleman, S. Thiboutot, J. M. Brannon, A. D. Hewitt, J. Lewis, S. Brochu, E. Diaz, M. R. Walsh, M. E. Walsh, S. Taylor, J. C. Lynch, J. Clausen, T. A. Ranney, C. A. Ramsey, C. A. Hayes, C. L. Grant, C. M. Collins, S. R. Bigl, S. Yost, and K. Dontsova (2006). Distribution and Fate of Energetics on DoD Test and Training Ranges: Final Report. U.S. Army Corps of Engineers ERDC TR-06-13. November 2006.

Perkins, J. S., and G. W. Miller (1983). "Mass stranding of *Steno bredanensis* in Belize." Biotropica 15(3): 235-236.

Perrin, W. F. (2008b). Pantropical spotted dolphin *Stenella attenuata*. In: Encyclopedia of Marine Mammals. W. F. Perrin, B. Wursig and J. G. M. Thewissen, Academic Press: 819-821.

Perrin, W. F. (2008c). Spinner dolphin *Stenella longirostris*. In: Encyclopedia of Marine Mammals. W. F. Perrin, B. Wursig and J. G. M. Thewissen, Academic Press: 1100-1103.

Perrin, W. F. (2001). "*Stenella attenuata*." Mammalian Species 683: 1-8.

Perrin, W. F. (1976). "First record of the melon-headed whale, *Peponocephala electra*, in the eastern Pacific, with a summary of world distribution." Fishery Bulletin 74(2): 457-458.

Perrin, W. F., and J. W. Gilpatrick, Jr. (1994). Spinner dolphin *Stenella longirostris* (Gray, 1828). In Handbook of Marine Mammals, Volume 5: The first book of dolphins. S. H. Ridgway and R. Harrison. San Diego, CA, Academic Press. 5: 99-128.

Perrin, W. F., and A. A. Hohn (1994). Pantropical spotted dolphin *Stenella attenuata*. In Handbook of Marine Mammals. S. H. Ridgway and R. Harrison. San Diego, CA, Academic Press. 5: 71-98.

Perrin, W. F., B. Würsig, and J. G. M. Thewissen (2009). Encyclopedia of Marine Mammals. Second Edition. Academic Press, Amsterdam.

Perrin, W. F., C. E. Wilson, and F. I. Archer II (1994a). Striped dolphin--*Stenella coeruleoalba* (Meyen, 1833). In Handbook of Marine Mammals. S. H. Ridgway and R. Harrison. San Diego, CA, Academic Press. 5: The First Book of Dolphins: 129-159.

Perrin, W. F., S. Leatherwood, and A. Collet (1994b). Fraser's dolphin Lagenodelphis hosei Fraser, 1956. Handbook of Marine Mammals, Volume 5: The first book of dolphins. S. H. Ridgway and R. Harrison. San Diego, California, Academic Press: 225-240.

Perrin, W. F., P. B. Best, W. H. Dawbin, K. C. Balcomb, R. Gambell, and G. J. B. Ross (1973). "Rediscovery of Fraser's dolphin *Lagenodelphis hosei*." Nature 241: 345-350.

Perry, S. L., D. P. DeMaster, and G. K. Silber (1999). "The great whales: history and status of six species listed as Endangered under the U.S. Endangered Species Act of 1973." Marine Fisheries Review 61(1): 1-74.

Perryman, W. L. (2008). Melon-headed whale *Peponocephala electra*. In: Encyclopedia of Marine Mammals. W. F. Perrin, B. Wursig and J. G. M. Thewissen, Academic Press: 719-721.

Perryman, W. L., and T. C. Foster (1980). *Preliminary Report on Predation by Small Whales, Mainly the False Killer Whale,* Pseudorca crassidens*, on Dolphins (*Stenella spp*. and* Delphinus delphis*) in the Eastern Tropical Pacific*. La Jolla, CA, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center: 9.

Perryman, W. L., D. W. K. Au, S. Leatherwood, and T. A. Jefferson (1994). Melon-headed whale *Peponocephala electra* Gray, 1846. Handbook of Marine Mammals, Volume 5: The first book of dolphins. S. H. Ridgway and R. Harrison, Academic Press: 363-386.

Pierce, G., M. Santos, C. Smeenk, A. Saveliev, and A. Zuur (2007). "Historical trends in the incidence of strandings of sperm whales (*Physeter macrocephalus*) on North Sea coasts: An association with positive temperature anomalies." Fisheries Research 87(2-3): 219-228.

Pitman, R. (2008a). Indo-Pacific beaked whale *Indopacetus pacificus*. In: Encyclopedia of Marine Mammals. W. F. Perrin, B. Wursig and J. G. M. Thewissen, Academic Press**:** 600-602.

Pitman, R. L. (1992). Sea turtle associations with flotsam in the eastern tropical Pacific Ocean. In M. Salmon and J. Wyneken (Eds.), Proceedings of the Eleventh Annual Workshop on Sea Turtle Biology and Conservation [Abstract]. (NOAA Technical Memorandum NMFS-SEFSC-302, pp. 94) U.S. Department of Commerce, National Oceanic and Atmospheric Administration and National Marine Fisheries Service.

Pitman, R. L. (1990). Pelagic distribution and biology of sea turtles in the eastern tropical Pacific. In T. H. Richardson, J. I. Richardson and M. Donnelly (Eds.), Proceedings of the Tenth Annual Workshop on Sea Turtle Biology and Conservation. (NOAA Technical Memorandum NMFS-SEFC-278, pp. 143-150). U.S. Department of Commerce, National Oceanic and Atmospheric Administration and National Marine Fisheries Service.

Pitman, R. L., and C. Stinchcomb (2002). "Rough-toothed dolphins (*Steno bredanensis*) as predators of mahi mahi (*Coryphaena hippurus*)." Pacific Science 56(4): 447-450.

Pitman, R. L., H. Fearnbach, R. LeDuc, J. W. Gilpatrick, Jr., J. K. B. Ford, and L. T. Ballance (2007). "Killer whales preying on a blue whale calf on the Costa Rica Dome: Genetics, morphometrics, vocalisations and composition of the group." Journal of Cetacean Research and Management 9(2): 151-157.

Pitman, R. L., D. W. K. Au, M. D. Scott, and J. M. Cotton (1988). *Observations of Beaked Whales (*Ziphiidae*) from the Eastern Tropical Pacific Ocean*, International Whaling Commission.

Plotkin, P. T., R. A. Byles, and D. W. Owens (1994). Post-breeding movements of male olive ridley sea turtles *Lepidochelys olivacea* from a nearshore breeding area. In K. A. Bjorndal, A. B. Bolton, D. A. Johnson and P. J. Eliazar (Eds.), Proceedings of the Fourteenth Annual Symposium on Sea Turtle Biology and Conservation [Abstract]. (NOAA Technical Memorandum NMFC-SEFSC-351) U.S. Department of Commerce, National Oceanic and Atmospheric Administration and National Marine Fisheries Service.

Polovina, J. J., I. Uchida, G. H. Balazs, E. Howell, D. M. Parker, and P. Dutton (2006). The Kuroshio Extension Bifurcation Region: A pelagic hotspot for juvenile loggerhead sea turtles. Deep-Sea Research II, 53, 326-339. doi: 10.1016/j.dsr2.2006.01.006.

Polovina, J. J., G. H. Balazs, E. A. Howell, D. M. Parker, M. P. Seki, and P. H. Dutton (2004). Forage and migration habitat of loggerhead (Caretta caretta) and olive ridley (*Lepidochelys olivacea*) sea turtles in the central North Pacific Ocean. Fisheries Oceanography, 13(1), 36-51.

Polovina, J. J., E. Howell, D. M. Parker, and G. H. Balazs (2002). Dive-depth distribution of loggerhead (*Caretta caretta*) and olive ridley (*Lepidochelys olivacea*) sea turtles in the central North Pacific: Might deep longline sets catch fewer turtles? Fishery Bulletin, 101(1), 189-193.

Polovina, J. J., E.,Howell, D. R. Kobayashi, and M. P. Seki (2001). The transition zone chlorophyll front, a dynamic global feature defining migration and forage habitat for marine resources. Progress in Oceanography, 49, 469-483.

Polovina, J. J., D. R. Kobayashi, D. M. Parker, M. P. Seki, and G. H. Balazs (2000). Turtles on the edge: movement of loggerhead turtles (*Caretta caretta*) along oceanic fronts, spanning longline fishing grounds in the central North Pacific, 1997-1998. Fisheries Oceanography, 9(1), 71-82.

Poole, M. M. (1995). Aspects of the behavioral ecology of spinner dolphins (*Stenella longirostris*) in the nearshore waters of Mo'orea, French Polynesia Ph.D. dissertation, University of California, Santa Cruz.

Popper, A. N., and M. C. Hastings (2009). Review Paper: The effects of anthropogenic sources of sound on fishes. *Journal of Fish Biology* (2009) 75, 455-489.

Pritchard, P. C. H. (1982). Nesting of the leatherback turtle, *Dermochelys coriacea*, in Pacific Mexico, with a new estimate of the world population status. Copeia, 1982(4), 741-747.

Pritchard, P. C. H. (1997). Evolution, phylogeny, and current status. In P. L. Lutz and J. A. Musick (Eds.), The Biology of Sea Turtles (pp. 1-28). Boca Raton, FL: CRC Press.

Pritchard, P. C. H., and P. T. Plotkin (1995). Olive ridley sea turtle, *Lepidochelys olivacea*. In P. T. Plotkin (Ed.), National Marine Fisheries Service and U.S. Fish and Wildlife Service Status Reviews of Sea Turtles Listed under the Endangered Species Act of 1973. (pp. 123-139). Silver Spring, MD: National Marine Fisheries Service.

Pryor, T., K. Pryor, and K. S. Norris (1965). “Observations on a pygmy killer whale (*Feresa attenuata* Gray) from Hawaii.” Journal of Mammalogy 46(3): 450-461.

RAND Corporation (2005). *Unexploded Ordnance Cleanup Costs. Implications of Alternative Protocols*.

Rankin, S., and J. Barlow (2007). “Sounds recorded in the presence of Blainville’s beaked whales, *Mesoplodon densirostris*, near Hawaii (L).” Journal of the Acoustical Society of America 122(1): 42-45.

Rankin, S., and J. Barlow (2005). “Source of the North Pacific “boing” sound attributed to minke whales.” Journal of the Acoustical Society of America 118: 3346-3351.

Rankin, S., T. F. Norris, M. A. Smultea, C. Oedekoven, A. M. Zoidis, E. Silva, and J. Rivers (2007). “A visual sighting and acoustic detections of minke whales, Balaenoptera acutorostrata (Cetacea: Balaenopteridae), in nearshore Hawaiian waters.” Pacific Science 61: 395-398.

Read, A. J. (2008). “The looming crisis: Interactions between marine mammals and fisheries.” Journal of Mammalogy 89(3): 541-548.

Reeves, R., S. Leatherwood, and R. Baird (2009). “Evidence of a possible decline since 1989 in false killer whales (*Pseudorca crassidens*) around the main Hawaiian Islands.” Pacific Science 63: 253-261.

Reeves, R. R., W. F. Perrin, B. L. Taylor, C. S. Baker, and S. L. Mesnick (2004). *Report of the Workshop on Shortcomings of Cetacean Taxonomy in Relation to Needs of Conservation and Management, April 30 - May 2, 2004 La Jolla, California*. La Jolla, CA, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center**:** 94.

Reeves, R. R., B. S. Stewart, P. J. Clapham, and J. A. Powell (2002). *National Audubon Society Guide to Marine Mammals of the World*. New York, NY, Alfred A. Knopf**:** 527.

Reich, K. J., K. A. Bjorndal, A. B. Bolten, and B. Witherington (2007). Do some loggerheads nesting in Florida have an oceanic foraging strategy? An assessment based on stable isotopes. In R. B. Mast, B. J. Hutchinson and A. H. Hutchinson (Eds.), Proceedings of the Twenty-fourth Annual Symposium on Sea Turtle Biology and Conservation [Abstract]. (NOAA Technical Memorandum NMFS-SEFSC-567, pp. 32) U.S. Department of Commerce, National Oceanic and Atmospheric Administration and National Marine Fisheries Service.

Reilly, S. B. (1990). “Seasonal changes in distribution and habitat differences among dolphins in the eastern tropical Pacific.” Marine Ecology Progress Series 66: 1-11.

Reilly, S. B., J. L. Bannister, P. B. Best, M. Brown, R. L. Brownell Jr., D. S. Butterworth, P. J. Clapham, J. Cooke, G. P. Donovan, J. Urbán, and A. N. Zerbini (2008). *Eubalaena japonica*. In: IUCN 2012. IUCN Red List of Threatened Species. Version 2012.1. <www.iucnredlist.org>. Downloaded on 29 September 2012.

Renaud, M. L., and J. A. Carpenter (1994). Movements and submergence patterns of loggerhead turtles (*Caretta caretta*) in the Gulf of Mexico determined through satellite telemetry. Bulletin of Marine Science, 55(1), 1-15.

Resendiz, A., B. Resendiz, W. J. Nichols, J. A. Seminoff, and N. Kamezaki (1998). First confirmed east-west transpacific movement of a loggerhead sea turtle, *Caretta caretta*, released in Baja California, Mexico. Pacific Science, 52(2), 151-153.

Rice, D. W. (1998). Marine mammals of the world: systematics and distribution. Society for Marine Mammalogy Special Publication. Lawrence, KS, Society for Marine Mammalogy: 231.

Rice, D. W. (1989). Sperm whale *Physeter macrocephalus* Linnaeus, 1758. In Handbook of Marine Mammals, Volume 4: River dolphins and the larger toothed whales. S. H. Ridgway and R. Harrison. San Diego, CA, Academic Press. 4: 177-234.

Rice, M. R., and G. H. Balazs (2008). Diving behavior of the Hawaiian green sea turtle (*Chelonia mydas*) during oceanic migrations. Journal of Experimental Marine Biology and Ecology, 356(1-2), 121-127. doi: 10.1016/j.jembe.2007.12.010.

Richardson, J. I., R. Bell, and T. H. Richardson (1999). Population ecology and demographic implications drawn from an 11-year study of nesting hawksbill turtles, Eretmochelys imbricata, at Jumby Bay, Long Island, Antigua, West Indies. *Chelonian Conservation and Biology 3*(2): 244-250.

Richmond, D. R., J. T. Yelverton, and E. R. Fletcher (1973). Far-field underwater-blast injuries produced by small charges. Washington, DC, Lovelace Foundation for Medical Education and Research, Defense Nuclear Agency: 108.

Ridgway S. H., E. G. Wever, J. G. McCormick, J. Palin, J. H. Anderson (1969). Hearing in the giant sea turtle, *Chelonia mydas*. Proceedings of the National Academy of Sciences USA 64:884-890.

Ritter, F. (2002). “Behavioural observations of rough-toothed dolphins (*Steno bredanensis*) off La Gomera, Canary Islands (1995-2000), with special reference to their interactions with humans.” Aquatic Mammals 28(1): 46-59.

Rivers, J. (2011). Sea turtles nesting and in-water sightings in the Hawaiian Islands. Personal communication with Julie Rivers, Pacific Fleet Marine Biologist via comments on the HSTT DEIS v1.

Robertson, K. M., and S. J. Chivers (1997). “Prey occurrence in pantropical spotted dolphins, *Stenella attenuata*, from the eastern tropical Pacific.” Fishery Bulletin 95(2): 334-348.

Rodacy, P. J., P. K. Walker, S. D. Reber, J. Phelan, and J. V. Andre (2000). *Explosive Detection in the Marine Environment and On Land Using Ion Mobility Spectroscopy: A Summary of Field Tests*. Sandia National Laboratories. Sandia Report SAND2000-0921. April 2000.

Rolland, R.M, Susan E. Parks, Kathleen E. Hunt, Manuel Castellote, Peter J. Corkeron, Douglas P. Nowacek, Samuel K. Wasser, and Scott D. Kraus (2012). Evidence that ship noise increases stress in right whales. *Proc. R. Soc. B Biological Sciences* 279, 2363-2368. doi: 10.1098/rspb.2011.2429.

Rosel, P. E., and H. Watts (2008). “Hurricane impacts on bottlenose dolphins in the northern Gulf of Mexico.” Gulf of Mexico Science 25(1): 88-94.

Ross, G. J. B. (1971). “Shark attack on an ailing dolphin *Stenella coeruleoalba* (Meyen).” South African Journal of Science 67: 413-414.

Ross, G. J. B., and S. Leatherwood (1994). Pygmy killer whale Feresa attenuata Gray, 1874. Handbook of Marine Mammals, Volume 5: The first book of dolphins. S. H. Ridgway and R. Harrison, Academic Press: 387-404.

Rowntree, V., J. Darling, G. Silber, and M. Ferrari (1980). "Rare sighting of a right whale (*Eubalaena glacialis*) in Hawaii." Canadian Journal of Zoology 58: 4.

Sakamoto, W., K. Sato, H. Tanaka, and Y. Naito (1993). Diving patterns and swimming environment of two loggerhead turtles during internesting. Nippon Suisan Gakkaishi 59(7):1129-1137.

Salden, D. R. (1989). An observation of apparent feeding by a sub-adult humpback whale off Maui, Hawaii. [Abstract]. Presented at the Eighth Biennial Conference on the Biology of Marine Mammals, Pacific Grove, CA. 7-11 December.

Salden, D., and J. Mickelsen (1999). Rare Sighting of a North Pacific Right Whale (Eubalaena glacialis) in Hawai'i. Pacific Science, 53(4), 341-345.

Salden, D. R., L. M. Herman, M. Yamaguchi, and F. Sato (1999). Multiple visits of individual humpback whales (*Megaptera novaeangliae*) between the Hawaiian and Japanese winter grounds. Canadian Journal of Zoology 77: 504-508.

Sale, A., P. Luschi, R. Mencacci, P. Lambardi, G. R. Hughes, G. C. Hays, and F. Papi (2006). Long-term monitoring of leatherback turtle diving behaviour during oceanic movements. Journal of Experimental Marine Biology and Ecology, 328, 197-210. doi: 10.1016/j.jembe.2005.07.006.

Salmon, M., T. T. Jones and K. W. Horch (2004). Ontogeny of diving and feeding behavior in juvenile seaturtles: Leatherback seaturtles (Dermochelys coriacea L) and green seaturtles (*Chelonia mydas L*) in the Florida current. Journal of Herpetology, 38(1), 36-43.

Santos, M. B., V. Martin, et al. (2007). "Insights into the diet of beaked whales from the atypical mass strandings in the Canary Islands in September 2002." Journal of the Marine Biological Association of the United Kingdom 87: 243-251.

Sarti-Martinez, A. L. (2000). Dermochelys coriacea. In IUCN 2009. IUCN Red List of Threatened Species. Version 2009.2 Retrieved from www.iucnredlist.org, 19 November 2009.

Sarti-Martinez, L., S. A. Eckert, T. N. Garcia, and A. R. Barragan (1996). Decline of the world's largest nesting assemblage of leatherback turtles. Marine Turtle Newsletter, 74, 2-5. Retrieved from http://www.seaturtle.org/mtn/archives/mtn74/mtn74p2.shtml.

Schilling, M. R., I. Seipt, M. T. Weinrich, S. E. Frohock, A. E. Kuhlberg, and P. J. Clapham (1992). "Behavior of individually identified sei whales *Balaenoptera borealis* during an episodic influx into the southern Gulf of Maine in 1986." Fishery Bulletin 90: 749-755.

Schlundt, C. E., J. J. Finneran, D. A. Carder, and S. H. Ridgway (2000). Temporary shift in masked hearing thresholds of bottlenose dolphins, Tursiops truncatus, and white whales, *Delphinapterus leucas*, after exposure to intense tones. Journal of the Acoustical Society of America, 107(6), 3496-3508.

Schmelzer, I. (2000). "Seals and seascapes: Covariation in Hawaiian monk seal subpopulations and the oceanic landscape of the Hawaiian Archipelago." Journal of Biogeography 27: 901-914.

Schofield, G., V. J. Hobson, M. K. S. Lilley, K. A. Katselidis, C. M. Bishop, P. Brown, and G. C. Hays (2010). Inter-annual variability in the home range of breeding turtles: Implications for current and future conservation management. Biological Conservation, 143(3), 722-730. doi:10.1016/j.biocon.2009.12.011.

Schroeder, B. A., A. M. Foley, and D. A. Bagley (2003). Nesting patterns, reproductive migrations, and adult foraging areas of loggerhead turtles. In A. B. Bolten and B. E. Witherington (Eds.), Loggerhead Sea Turtles (pp. 114-124). Washington, DC: Smithsonian Institution Press.

Scott, M. D. and S. J. Chivers (1990). Distribution and herd structure of bottlenose dolphins in the eastern tropical Pacific Ocean. In: The Bottlenose Dolphin. S. Leatherwood and R. R. Reeves, Academic Press**:** 387-402.

Sears, R., and W. F. Perrin (2008). Blue whale. In: Encyclopedia of Marine Mammals. W. F. Perrin, B. Wursig and J. G. M. Thewissen. San Diego, CA, Academic Press: 120-124.

Sekiguchi, K., N. T. W. Klages, and P. B. Best (1992). "Comparative analysis of the diets of smaller odontocete cetaceans along the coast of southern Africa." South African Journal of Marine Science 12: 843-861.

Seminoff, J. A., and Marine Turtle Specialist Group Green Sea Turtle Task Force (2004). Marine Turtle Specialist Group Review: 2004 Global Status Assessment, Green sea turtle (*Chelonia mydas*). (pp. 71) The World Conservation Union (IUCN) Species Survival Commission, Red List Programme.

Seminoff, J. A., W. J. Nichols, A. Resendiz, and L. Brooks (2003). Occurrence of hawksbill turtles, *Eretmochelys imbricata* (Reptilia: Cheloniidae), near the Baja California peninsula, Mexico. Pacific Science, 57(1), 9-16.

Shallenberger, E. W. (1981). *The Status of Hawaiian Cetaceans*. Kailua, HI, Manta Corporation: 79.

Shane, S. H. (1990). Comparison of bottlenose dolphin behavior in Texas and Florida, with a critique of methods for studying dolphin behavior. In: The Bottlenose Dolphin. S. Leatherwood and R. R. Reeves. San Diego, CA, Academic Press**:** 541-558.

Shankar, K., J. Ramadevi, B. C. Choudhary, L. Singh, and R. K. Aggarwal (2004). Phylogeography of olive ridley turtles (*Lepidochelys olivacea*) on the east coast of India: implications for conservation theory. Molecular Ecology, 13 1899-1909. doi: 10.1111/j.1365-294X.2004.02195.x.

Skillman, R. A., and G. H. Balazs (1992). Leatherback turtle captured by ingestion of squid bait on swordfish longline. Fishery Bulletin, 90, 807-808.

Skillman, R. A., and P. Kleiber (1998). Estimation of Sea Turtle Take and Mortality in the Hawai'i-based Longline Fishery, 1994-96. (NOAA Technical Memorandum NMFS-SWFSC-257, pp. 52) U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service and Southwest Fisheries Science Center.

Smith, S. S., and D. E. Marx Jr. (2016). De-facto marine protection from a Navy bombing range: Farallon De Medinilla, Mariana Archipelago, 1997 to 2012. Marine Pollution Bulletin 102 (2016) 187-198.

Smith, B. D., G. Braulik, S. Strindberg, R. Mansur, M. A. A. Diyan, and B. Ahmed (2009). "Habitat selection of freshwater-dependent cetaceans and the potential effects of declining freshwater flows and sea level rise in waterways of the Sundarbans mangrove forest, Bangladesh." Aquatic Conservation: Marine and Freshwater Ecosystems 19: 209-225.

Smith, M. E., A. S. Kane, and A. N. Popper (2004). Noise-induced stress response and hearing loss in goldfish (*Carassius auratus*). *The Journal of Experimental Biology* 207, 427–435.

Smultea, M. A. (1994). "Segregation by humpback whale (*Megaptera novaeangliae*) cows with a calf in coastal habitat near the island of Hawaii." Canadian Journal of Zoology 72: 805-811.

Smultea, M. A., T. A. Jefferson, and A. M. Zoidis (2010). "Rare sightings of a Bryde's whale (*Balaenoptera edeni*) and sei whales (*B. borealis*) (Cetacea: Balaenopteridae) northeast of O'ahu, Hawai'i." Pacific Science 64: 449-457.

Smultea, M. A., J. L. Hopkins, and A. M. Zoidis (2008b). *Marine Mammal and Sea Turtle Monitoring Survey in Support of Navy Training Exercises in the Hawai'i Range Complex November 11-17, 2007*. C. R. Organization. Oakland, CA: 62.

Smultea, M. A., J. L. Hopkins, and A. M. Zoidis (2007). *Marine Mammal Visual Survey in and near the Alenuihaha Channel and the Island of Hawai'i: Monitoring in Support of Navy Training Exercises in the Hawai'i Range Complex, January 27 – February 2, 2007*. Oakland, CA**:** 63.

Soma, M. (1985). Radio biotelemetry system applied to migratory study of turtle. Journal of the Faculty of Marine Science and Technology, 21, 47-56.

Southall, B., J. Calambokidis, P. Tyack, D. Moretti, A. Friedlaender, S. DeRuiter, J. Goldbogen, E. Falcone, G. Schorr, A. Douglas, A. Stimpert, J. Hildebrand, C. Kyburg, R. Carlson, T. Yack, and J. Barlow (2012). Biological and Behavioral Response Studies of Marine Mammals in Southern California, 2011 ("SOCAL-11"), Final Project Report, 8 March 2012. Manuscript on file.

Southall, B., J. Calambokidis, P. Tyack, D. Moretti, J. Hildebrand, C. Kyburg, R. Carlson, A. S. Friedlaender, E. A. Falcone, G. S. Schorr, A. Douglas, S. L. Deruiter, J. A. Goldbogen, and J. Barlow (2011). Biological and Behavioral Response Studies of Marine Mammals in Southern California, 2010 ("SOCAL-10") *SOCAL-BRS* [Project Report]. (pp. 29).

Southall, B. L., P. L. Tyack, D. Moretti, C. Clark, D. Claridge, and I. Boyd (2009). Behavioral responses of beaked whales and other cetaceans to controlled exposures of simulated sonar and other sounds, 18th Biennial Conference on the Biology of Marine Mammals. Quebec City, Quebec, Canada.

Southall, B. L., A. E. Bowles, W. T. Ellison, J. J. Finneran, R. L. Gentry, C. R. Greene Jr., D. Kastak, D. R. Ketten, J. H. Miller, P. E. Nachtigall, W. J. Richardson, J. A. Thomas, and P. L. Tyack (2007). Marine Mammal Noise Exposure Criteria: Initial Scientific Recommendations. Aquatic Mammals 33:411-521.

Southwood, A. L., R. D. Andrews, M. E. Lutcavage, F. V. Paladino, N. H. West, R. H. George, and D. R. Jones (1999). Heart rates and diving behavior of leatherback sea turtles in the eastern Pacific Ocean. Journal of Experimental Biology, 202, 1115-1125.

Spotila, J. R., R. D. Reina, A. C. Steyermark, P. T. Plotkin, and F. V. Paladino (2000). Pacific leatherback turtles face extinction. Nature, 405, 529-530.

Spotila, J. R., A. E. Dunham, A. J. Leslie, A. C. Steyermark, P. T. Plotkin, and F. V. Paladino (1996). Worldwide population decline of Dermochelys coriacea: Are leatherback turtles going extinct? Chelonian Conservation and Biology, 2(2), 209-222.

Stadler, J. H., and D. P. Woodbury (2009). Assessing the effects of fishes from pile driving: Application of new hydroacoustic criteria. *Inter-Noise 2009*, Ottawa, Canada. August 23-26, 2009.

Stafford, K., D. Bohnenstiehl, M. Tolstoy, E. Chapp, D. Mellinger, and S. Moore (2004). "Antarctic-type blue whale calls recorded at low latitudes in the Indian and eastern Pacific oceans." Deep-Sea Research I 51: 1337-1346.

Stancyk, S. E. (1982). Non-human predators of sea turtles and their control. In K. A. Bjorndal (Ed.), Biology and Conservation of Sea Turtles (pp. 139-152). Washington, DC: Smithsonian Institution Press.

Starbird, C. H., A. Baldridge, and J. T. Harvey (1993). Seasonal occurrence of leatherback sea turtles (*Dermochelys coriacea*) in the Monterey Bay region, with notes on other sea turtles, 1986-1991. California Fish and Game, 79(2), 54-62.

Steiger, G., J. Calambokidis, J. Straley, L. Herman, S. Cerchio, D. Salden, J. Urban-R, J. Jacobsen, O. Ziegesar, K. Balcomb, C. Gabriele, M. Dahlheim, S. Uchida, J. Ford, P. Ladron de Guevara-P, M. Yamaguchi, and J. Barlow (2008). "Geographic variation in killer whale attacks on humpback whales in the North Pacific: implications for predation pressure." Endangered Species Research 4(3): 247- 256.

Stewart, B. S., G. A. Antonelis, J. D. Baker, and P. K. Yochem (2006). “Foraging biogeography of Hawaiian monk seals in the Northwestern Hawaiian Islands.” Atoll Research Bulletin 543: 131–146.

Storch, S., R. P. Wilson, Z. M. Hillis-Starr, and D. Adelung (2005). Cold-blooded divers: temperature dependent dive performance in the wild hawksbill turtle *Eretmochelys imbricata*. Marine Ecology Progress Series, 293, 263-271.

Suarez, A., P. H. Dutton, and J. Bakarbessy (2000). Leatherback (Dermochelys coriacea) nesting on the north Vogelkop coast of Irian Jaya, Indonesia. In H. Kalb and T. Wibbels (Eds.), Proceedings of the Nineteenth Annual Symposium on Sea Turtle Biology and Conservation [Abstract]. (NOAA Technical Memorandum NMFS-SEFSC-443, pp. 260) U.S. Department of Commerce, National Oceanic and Atmospheric Administration and National Marine Fisheries Service.

Thompson, P.M., D. Lusseau, T. Barton, D. Simmons, J. Rusin, and H. Bailey (2010). Assessing the responses of coastal cetaceans to the construction of offshore wind turbines. Marine Pollution Bulletin 60:1200-1208.

Turtle Expert Working Group (2007). An Assessment of the Leatherback Turtle Population in the Atlantic Ocean. (NOAA Technical Memorandum NMFS-SEFSC-555, pp. 116) U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service and Southeast Fisheries Science Center.

Twiss, J. R., Jr. and R. R. Reeves (1999). Conservation and Management of Marine Mammals. Washington, D.C., Smithsonian Institution Press: 471.

Tyack, P. L. (2009). “Human-generated sound and marine mammals.” Physics Today: 39-44.

Tyack, P.L. (2009a). Acoustic playback experiments to study behavioral responses of free-ranging marine animals to anthropogenic sound. Marine Ecology Progress Series, 395, 13. 10.3354/meps08363.

Tyack, P., W. Zimmer, D. Moretti, B. Southall, D. Claridge, J. Durban, and I. Boyd (2011). Beaked Whales Respond to Simulated and Actual Navy Sonar. [electronic version]. PLoS ONE, 6(3), 15. 10.1371/journal.pone.0017009.

U.S. Commission on Ocean Policy (2004). *An Ocean Blueprint for the 21st Century*. Final Report. Washington, DC 2004. ISBN#0–9759462–0–X.

U.S. Department of the Navy (2014). Commander Task Force 3rd and 7th Fleet Navy Marine Species Density Database. NAVFAC Pacific Technical Report. Naval Facilities Engineering Command Pacific, Pearl Harbor, HI.

U.S. Department of the Navy (2013). Hawaii-Southern California Training and Testing Essential Fish Habitat Assessment. August 2013.

U.S. Department of the Navy (2011). Marine Species Monitoring for the U.S. Navy’s Hawaii Range Complex and the Southern California Range Complex, 2011 Annual Report. Available at www.nmfs.noaa.gov/pr/permits/incidental.htm#applications.

U.S. Department of the Navy (2009a). Marine Species Monitoring for the U.S. Navy’s Hawaii Range Complex and the Southern California Range Complex, 2009 Annual Report. Available at www.nmfs.noaa.gov/pr/permits/incidental.htm#applications.

U.S. Department of the Navy (2006). Rim of the Pacific Exercise After Action Report: Analysis of Effectiveness of Mitigation and Monitoring Measures as Required Under the Marine Mammals Protection Act (MMPA) Incidental Harassment Authorization and the National Defense Exemption from the Requirements of the MMPA for Mid-Frequency Active Sonar Mitigation Measures**:** 60.

U.S. Department of the Navy (2002). Environmental Assessment for the Hawaiian Islands Shallow Water Training Range [Final Report]. Pearl Harbor, Hawaii. Prepared by Commander in Chief U.S. Pacific Fleet.

U.S. Department of the Navy (2001a). Integrated Natural Resources Management Plan: Pacific Missile Range Facility Hawaii [Final Report]. (pp. 376). Honolulu, Hawaii. Prepared by Belt Collins Hawaii Ltd. Prepared for Commander, Navy Region Hawaii.

U.S. Department of the Navy (2001b). "Appendix D: Physical impacts of explosions on marine mammals and turtles," in *Final Environmental Impact Statement: Shock Trial of the Winston S. Churchill (DDG 81)*, edited by J. James C.Craig (Department of the Navy and U.S. Department of Commerce, NOAA, National Marine Fisheries Service), pp. 1-43.

Van Dam, R. P., and C. E. Diez (1997). Diving behavior of immature hawksbill turtles (Eretmochelys imbricata) in a Caribbean reef habitat. Coral reefs (1997) 16:133-138.

Van Dam, R. P., and C. E. Diez (1996). Diving behavior of immature hawksbills (*Eretmochelys imbricata*) in a Caribbean cliff-wall habitat. Marine Biology, 127, 171-178.

Van Waerebeek, K., F. Felix, B. Haase, D. Palacios, D. M. Mora-Pinto, and M. Munoz-Hincapie (1998). "Inshore records of the striped dolphin, *Stenella coeruleoalba*, from the Pacific coast of South America." Reports of the International Whaling Commission 48: 525-532.

Wade, P.R. (1994). Abundance and Population Dynamics of Two Eastern Pacific Dolphins, *Stenella attenuata* and *Stenella longirostris orientalis*. (Doctoral dissertation). University of California, San Diego.

Wade, P. R., and T. Gerrodette (1993). "Estimates of cetacean abundance and distribution in the eastern tropical Pacific." Reports of the International Whaling Commission 43: 477-493.

Wade, P. R., J. M. Ver Hoef, and D. P. DeMaster (2009). "Mammal-eating killer whales and their prey — trend data for pinnipeds and sea otters in the North Pacific Ocean do not support the sequential megafaunal collapse hypothesis." Marine Mammal Science 25(3): 737-747.

Walker, S. W., C. L. Osburn, T. J. Boyd, L. J. Hamdan, R. B. Coffin, M. T. Montgomery, J. P. Smith, Q. X. Li, C. Hennessee, F. Monteil, and J. Hawari (2006). *Mineralization of 2,4,6-Trinitrotoluene (TNT) in Coastal Waters and Sediments*. Naval Research Laboratory NRL/FR/6114-06-10, 135. August 21, 2006.

Wallace, B. P., R. L. Lewison, S. L. McDonald, R. K. McDonald, C. Y. Kot, S. Kelez, and L. B. Crowder (2010). Global patterns of marine turtle bycatch. Conservation Letters, 3(3), 131-142. doi: 10.1111/j.1755-263X.2010.00105.x.

Walsh, Michael R. (2007). *Explosives Residues Resulting from the Detonation of Common Military Munitions: 2002-2006. Final Report*. U.S. Army Corps of Engineers ERDC/CRREL TR-07-2. February 2007.

Wang, J. Y., and S. C. Yang (2006). "Unusual cetacean stranding events of Taiwan in 2004 and 2005." Journal of Cetacean Research and Management 8(3): 283-292.

Wang, J. Y., S. C. Yang, and H. C. Liao (2001). "Species composition, distribution and relative abundance of cetaceans in the waters of southern Taiwan: Implications for conservation and eco-tourism." Journal of the National Parks of Taiwan 11(2): 136-158.

Waring, G. T., T. Hamazaki, D. Sheehan, G. Wood, and S. Baker (2001). "Characterization of beaked whale (Ziphiidae) and sperm whale (*Physeter macrocephalus*) summer habitat in shelf-edge and deeper waters off the northeast U.S." Marine Mammal Science **17**(4): 703-717.

Watkins, W. A., M. A. Daher, G. M. Reppucci, J. E. George, D. L. Martin, N. A. DiMarzio, and D. P. Gannon (2000). "Seasonality and distribution of whale calls in the North Pacific." Oceanography 13(1): 62-67.

Weller, D. W. (2008). Predation on marine mammals. In Encyclopedia of Marine Mammals. W. F. Perrin, B. Würsig and J. G. M. Thewissen. San Diego, CA, Academic Press**:** 923-931.

Weller, D. W., B. Wursig, H. Whitehead, J. C. Norris, S. K. Lynn, R. W. Davis, N. Clauss, and P. Brown (1996). "Observations of an interaction between sperm whales and short-finned pilot whales in the Gulf of Mexico." Marine Mammal Science 12(4): 588-593.

Wells, R. S., and M. D. Scott (2008). Common bottlenose dolphin *Tursiops truncatus*. In: Encyclopedia of Marine Mammals. W. F. Perrin, W. B. and J. G. M. Thewissen, Academic Press**:** 249-255.

Wells, R. S., and M. D. Scott (1999). Bottlenose dolphin *Tursiops truncatus* (Montagu, 1821). In: Handbook of Marine Mammals, Volume 6: The Second Book of Dolphins and the Porpoises. S. H. Ridgway and R. Harrison. San Diego, CA, Academic Press**:** 137-182.

Wells, R. S., C. A. Manire, L. Byrd, D. R. Smith, J. G. Gannon, D. Fauqiuer, and K. D. Mullin (2009). "Movements and dive patterns of a rehabilitated Risso's dolphin, Grampus griseus, in the Gulf of Mexico and Atlantic Ocean." Marine Mammal Science 25(2): 420-429.

Wells, R. S., J. B. Allen, S. Hofmann, K. Bassos-Hull, D. A. Fauquier, N. B. Barros, R. E. DeLynn, G. Sutton, V. Socha, and M. D. Scott (2008). Consequences of injuries on survival and reproduction of common bottlenose dolphins (*Tursiops truncatus*) along the west coast of Florida. Marine Mammal Science 24(4): 774-794.

Werth, A. J. (2006a). "Mandibular and dental variation and the evolution of suction feeding in Odontoceti." Journal of Mammalogy 87(3): 579-588.

Werth, A. J. (2006b). "Odontocete suction feeding: Experimental analysis of water flow and head shape." Journal of Morphology 267: 1415-1428.

West, K. L., S. Sanchez, D. Rotstein, K. M. Robertson, S. Dennison, G. Levine, and B. Jensen (2012). A Longman's beaked whale (*Indopacetus pacificus*) strands in Maui, Hawaii, with first case of morbillivirus in the central Pacific. Marine Mammal Science, n/a-n/a. 10.1111/j.1748-7692.2012.00616.x Retrieved from http://dx.doi.org/10.1111/j.1748-7692.2012.00616.x.

West, K. L., W. A. Walker, R. W. Baird, W. White, G. Levine, E. Brown, and D. Schofield (2009). "Diet of pygmy sperm whales (*Kogia breviceps*) in the Hawiian Archipelago." Marine Mammal Science 25(4): 931-943.

Western Pacific Regional Fishery Management Council (WPRFMC) (2009a). *Fishery Ecosystem Plan for the Hawaii Archipelago*. September 4, 2009.

Western Pacific Regional Fishery Management Council (WPRFMC) (2009b). *Fishery Ecosystem Plan for Pacific Pelagic Fisheries of the Western Pacific Region*. September 24, 2009.

Whitehead, H. (2003). *Sperm Whales: Social Evolution in the Ocean*, University of Chicago Press**:** 431.

Whitehead, H., A. Coakes, N. Jaquet, and S. Lusseau (2008). "Movements of sperm whales in the tropical Pacific." Marine Ecology Progress Series 361: 291-300.

Witherington, B., and S. Hirama (2006). Sea turtles of the epi-pelagic *Sargassum* drift community. In M. Frick, A. Panagopoulou, A. F. Rees and K. Williams (Eds.), Book of Abstracts. Twenty-sixth Annual Symposium on Sea Turtle Biology and Conservation (Abstract, pp. 209). Athens, Greece: International Sea Turtle Society.

Witt, M. J., L. A. Hawkes, M. H. Godfrey, B. J. Godley, and A. C. Broderick (2010). Predicting the impacts of climate change on a globally distributed species: the case of the loggerhead turtle. Journal of Experimental Biology, 213(6), 901-911. doi: 10.1242/jeb.038133.

Witzell, W. N. (1983). Synopsis of Biological Data on the Hawksbill Turtle *Eretmochelys imbricata* (Linnaeus, 1766). (FAO Fisheries Synopsis 137, pp. 78). Rome, Italy: Food and Agriculture Organization of the United Nations.

Wood, F., and J. Wood (1993). Release and recapture of captive-reared green sea turtles, *Chelonia mydas*, in the waters surrounding the Cayman Islands. Herpetological Journal 3:84-89.

Wright, D. G. (1982). A Discussion Paper on the Effects of Explosives on Fish and Marine Mammals in the Waters of the Northwest Territories *Canadian Technical Report of Fisheries and Aquatic Sciences*. (pp. 1-16). Winnipeg, Manitoba: Western Region Department of Fisheries and Oceans.

Würsig, B., and W. J. Richardson (2009). Noise, effects of. Pp. 765–772. In: Perrin, W.F., Würsig, B., and J.G.M. Thewissen, Eds. The Encyclopedia of Marine Mammals, Ed. 2. Academic/Elsevier Press, San Diego, Ca. 1316 pp.

Wursig, B., T. A. Jefferson, and D. J. Schmidly (2000). The Marine Mammals of the Gulf of Mexico, Texas A&M University Press**:** 232.

Wysocki, L. E., J. P. Dittami, and F. Ladich (2006). Ship noise and cortisol secretion in European freshwater fishes. *Biological Conservation* 128 (2006), pp 501–508.

Yamada, T. K. (1997). "Strandings of cetacea to the coasts of the Sea of Japan - with special reference to *Mesoplodon stejnegeri*." IBI Reports 7: 9-20.0

Yelverton, J. T., and D. R. Richmond (1981). Underwater Explosion Damage Risk Criteria for Fish, Birds, and Mammals, 102nd Meeting of the Acoustical Society of America Journal of the Acoustical Society of America, Miami Beach, Florida. pp. S84.

Yelverton, J. T., D. R. Richmond, W. Hicks, K. Saunders, and E. R. Fletcher (1975). The Relationship Between Fish Size and Their Response to Underwater Blast, in: Defense Nuclear Agency (Ed.), Lovelace Foundation for Medical Education and Research, Washington, D.C. pp. 40.

Yelverton, J. T., D. R. Richmond, E. R. Fletcher, R. K. Jones (1973). Safe distances from underwater explosions for mammals and birds, Lovelace Foundation for Medical Education and Research, Albuquerque, New Mexico. pp. 66.

Young, G. A. (1991). *Concise Methods for Predicting the Effects of Underwater Explosions on Marine Life*. Naval Surface Weapons Center, Research and Technology Department, Dahlgren, Virginia. July 1, 1991.

Yudhana, A., J. Din, A. S. Sundari, and R. B. R. Hassan (2010). Green turtle hearing identification based on frequency spectral analysis. *Applied Physics Research 2,* 125-134.

Zug, G. R., M. Chaloupka, and G. H. Balazs (2006). Age and growth in olive ridley sea turtles (*Lepidochelys olivacea*) from the North-central Pacific: a skeletochronological analysis. Marine Ecology, 27, 263-270. doi: 10.1111/j.1439-0485.2006.00109.x.

Zug, G. R., and J. F. Parham (1996). Age and growth in leatherback turtles Dermochelys coriacea (Testudines: Dermochelyidae): a skeletochronological analysis. Chelonian Conservation and Biology, 2(2), 244-249.

APPENDIX A

ACOUSTIC MODELING METHODOLOGY

This page is intentionally blank.

Long Range Strike WSEP
MMPA and ESA Acoustic Impact Modeling: Modeling Appendix

Submitted by:

Leidos

To:

Air Force Civil Engineer Center
AFCEC/CZN

In response to tasking associated with:
Task Order CK02 under Contract W912BU-12-D-0027

Leidos Program Manager & Technical POC:
Dr. Brian Sperry
Marine Sciences R&D Division
4001 N. Fairfax Dr.
Arlington, VA 22203
Office: 703-907-2551
Fax: 703-276-3121
Email: Brian.J.Sperry@leidos.com

June 2016

Table of Contents

List of Tables

List of Figures

APPENDIX A
MMPA AND ESA ACOUSTIC IMPACT MODELING

A.1 BACKGROUND AND OVERVIEW

A.1.1 Federal Regulations Affecting Marine Animals

All marine mammals are protected under the Marine Mammal Protection Act (MMPA). The MMPA prohibits, with certain exceptions, the take of marine mammals in U.S. waters and by U.S. citizens on the high seas, and the importation of marine mammals and marine mammal products into the U.S.

The Endangered Species Act of 1973 (ESA) provides for the conservation of species that are endangered or threatened throughout all or a significant portion of their range, and the conservation of their ecosystems. A "species" is considered endangered if it is in danger of extinction throughout all or a significant portion of its range. A species is considered threatened if it is likely to become an endangered species within the foreseeable future. Some marine mammals, already protected under MMPA, are also listed as either endangered or threatened under ESA, and are afforded special protections. In addition, all sea turtles are protected under the ESA.

Actions involving sound in the water may have the potential to harass marine animals in the surrounding waters. Demonstration of compliance with the MMPA and ESA, using best available science, has been assessed using criteria and thresholds accepted or negotiated, and described here.

Sections of the MMPA (16 USC 1361 et seq.) direct the Secretary of Commerce to allow, upon request, the incidental, but not intentional, taking of small numbers of marine mammals by U.S. citizens who engage in a specified activity, other than commercial fishing, within a specified geographical region. Through a specific process, if certain findings are made and regulations are issued or, if the taking is limited to harassment, notice of a proposed authorization is provided to the public for review.

Authorization for incidental takings may be granted if National Marine Fisheries Service (NMFS) finds that the taking will have no more than a negligible impact on the species or stock(s), will not have an immitigable adverse impact on the availability of the species or stock(s) for subsistence uses, and that the permissible methods of taking, and requirements pertaining to the mitigation, monitoring and reporting of such taking are set forth.

NMFS has defined negligible impact in 50 CFR 216.103 as 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 effects on annual rates of recruitment or survival.

Subsection 101(a)(5)(D) of the MMPA established an expedited process by which citizens of the United States can apply for an authorization to incidentally take small numbers of marine mammals by harassment. The National Defense Authorization Act of 2004 (NDAA) (Public Law 108-136) removed the small numbers limitation and amended the definition of "harassment" as it applies to a military readiness activity to read as follows:

> (i) *any act that injures or has the significant potential to injure a marine mammal or marine mammal stock in the wild [Level A Harassment]; or*
> (ii) *any act that disturbs or is likely to disturb a marine mammal or marine mammal stock in the wild by causing disruption of natural behavioral patterns, including, but not limited to, migration, surfacing, nursing, breeding, feeding, or sheltering, to a point where such behavioral patterns are abandoned or significantly altered [Level B Harassment].*

The primary potential impact to marine mammals from underwater acoustics is Level A and Level B harassment, as defined by the MMPA from noise. Potential impacts to sea turtles from underwater acoustic exposure are primarily behavioral responses and impairment, with some potential for injury, and a very small potential for mortality.

A.1.2 Development of Animal Impact Criteria

A.1.2.1 Marine Mammals

For explosions of ordnance planned for use in the Long Range Strike WSEP mission area, in the absence of any mitigation or monitoring measures, there is a small chance that a marine mammal could be injured or killed when exposed to the energy generated from an explosive force. Analysis of noise impacts is based on criteria and thresholds initially presented in U.S. Navy Environmental Impact Statements for ship shock trials of the Seawolf submarine and the Winston Churchill (DDG 81), and subsequently adopted by NMFS.

Mortality

Lethal impact determinations currently incorporate species-specific thresholds that are based on the level of impact that would cause extensive lung injury from which one percent of exposed animals would not recover (Finneran and Jenkins, 2012). The threshold represents the expected onset of mortality, where 99 percent of exposed animals would be expected to survive. The lethal exposure level of blast noise, associated with the positive impulse pressure of the blast, is expressed as Pascal-seconds (Pa·s) and is determined using the Goertner (1982) modified positive impulse equation. This equation incorporates sound propagation, source/animal depths, and the mass of a newborn calf of the affected species. The Goertner equation used in the acoustic model to develop mortality impact analysis, is as follows:

$$I_M(M,D) = 91.4M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/2}$$

$I_M(M,D)$	mortality threshold, expressed in terms of acoustic impulse (Pa·s)
M	Animal mass (Table D-1)
D	Water depth (m)

Level A Harassment

Non-lethal injurious impacts (Level A Harassment) are defined in those documents as onset of slight lung injury, gastro-intestinal (GI) tract damage, and permanent (auditory) threshold shift (PTS).

The criteria for onset of slight lung injury were established using partial impulse because the impulse of an underwater blast wave was the parameter that governed damage during a study using mammals, not peak pressure or energy (Yelverton, 1981). Goertner (1982) determined a way to calculate impulse values for injury at greater depths, known as the Goertner "modified" impulse pressure. Those values are valid only near the surface because as hydrostatic pressure increases with depth, organs like the lung, filled with air, compress. Therefore the "modified" impulse pressure thresholds vary from the shallow depth starting point as a function of depth.

The shallow depth starting points for calculation of the "modified" impulse pressures are mass-dependent values derived from empirical data for underwater blast injury (Yelverton, 1981). During the calculations, the lowest impulse and body mass for which slight, and then extensive, lung injury found during a previous study (Yelverton et al, 1973) were used to determine the positive impulse that may cause lung injury. The Goertner model is sensitive to mammal weight such that smaller masses have lower thresholds for positive impulse so injury and harassment will be predicted at greater distances from the source for them. The equation used for determination of slight lung injury is:

$$I_S(M,D) = 39.1M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/2},$$

where M is animal mass (kg), D is animal depth (m), and the units of I_s are Pa-s. Following Finneran and Jenkins (2012), the representative mass for each species is taken to be that of an average newborn calf or pup for that species.

The criterion for slight injury to the GI tract was found to be a limit on peak pressure and independent of the animal's size (Goertner, 1982). A threshold of 103 psi (237 dB re 1 μPa) is used for all marine mammals. This level at which slight contusions to the GI tract were reported from small charge tests (Richmond *et al.,* 1973).

Two thresholds are used for PTS, one based on sound exposure level (SEL) and the other on the sound pressure level (SPL) of an underwater blast. Thresholds follow the approach of Southall et al. (2007). The threshold producing either the largest Zone of Influence (ZOI) or higher exposure levels is then used as the more protective of the dual thresholds. In most cases, the weighted total energy flux density (EFD) is more conservative that the largest EFD in any single 1/3-octave band used in earlier models. Type II weighting functions are applied for each cetacean functional hearing group and Type I weighting functions are applied for phocids such that the PTS thresholds are as follows:

Low-frequency (LF) Cetaceans
- SEL (Type II weighted): 187 decibels referenced to 1 microPascal-squared – seconds (dB re 1 $\mu Pa^2 \cdot s$)
- Peak SPL (unweighted): 230 decibels referenced to 1 microPascal (dB re 1 μPa)

Mid-frequency (MF) Cetaceans
- SEL (Type II weighted): 187 dB re 1 $\mu Pa^2 \cdot s$
- Peak SPL (unweighted): 230 dB re 1 μPa

High-frequency (HF) Cetaceans
- SEL (Type II weighted): 161 dB re 1 $\mu Pa^2 \cdot s$
- Peak SPL (unweighted): 201 dB re 1 μPa

Phocids (In-Water)
- SEL (Type I weighted) of 192 dB re 1 $\mu Pa^2 \cdot s$
- Peak SPL (unweighted) of 218 dB re 1 μPa

Level B Harassment

Level B (non-injurious) Harassment includes temporary (auditory) threshold shift (TTS), a slight, recoverable loss of hearing sensitivity. One criterion used for TTS, the total Type II weighted EFD of the signal, is a threshold of 172 dB re 1 μPa^2-s for LF and MF cetaceans. A second criterion, a maximum allowable peak pressure of 23 psi (224 dB re 1 μPa), has recently been established by NMFS to provide a more conservative range for TTS when the explosive or animal approaches the sea surface, in which case explosive energy is reduced, but the peak pressure is not. NMFS applies the more conservative of these two. For species where no data exist, TTS thresholds are based on the most closely related species for which data are available. The TTS thresholds for each functional hearing group are as follows:

LF Cetaceans

- SEL (Type-II weighted) of 172 dB re 1 $\mu\text{Pa}^2\cdot\text{s}$
- Peak SPL (unweighted) of 224 dB re 1 μPa

MF Cetaceans

- SEL (Type II weighted) of 172 dB re 1 $\mu\text{Pa}^2\cdot\text{s}$
- Peak SPL (unweighted) of 224 dB re 1 μPa

HF Cetaceans

- SEL (Type II weighted) of 146 dB re 1 $\mu\text{Pa}^2\cdot\text{s}$
- Peak SPL (unweighted) of 195 dB re 1 μPa

Phocids (In-Water)

- SEL (Type I weighted) of 177 dB re 1 $\mu\text{Pa}^2\cdot\text{s}$
- Peak SPL (unweighted) of 212 dB re 1 μPa

Level B Behavioral Harassment

For multiple successive explosions, the acoustic criterion for non-TTS behavioral disturbance is used to account for behavioral effects significant enough to be judged as harassment, but occurring at lower sound energy levels than those that may cause TTS. The threshold for behavioral disturbance is set 5 dB below the Type II weighted total EFD-based TTS threshold, or 167 dB re 1 μPa^2-s. This is based on observations of behavioral reactions in captive dolphins and belugas occurring at exposure levels approximately 5 dB below those causing TTS after exposure to pure tones (Schlundt et al., 2000). The behavioral impacts thresholds for all functional hearing groups of marine mammals exposed to multiple, successive detonations are:

LF Cetaceans

- SEL (Type II weighted) of 167 dB re 1 $\mu\text{Pa}^2\cdot\text{s}$

MF Cetaceans

- SEL (Type II weighted) of 167 dB re 1 $\mu\text{Pa}^2\cdot\text{s}$

HF Cetaceans

- SEL (Type II weighted) of 141 dB re 1 $\mu\text{Pa}^2\cdot\text{s}$

Phocids (In-Water)

- SEL (Type I weighted) of 172 dB re 1 $\mu\text{Pa}^2\cdot\text{s}$

Table A-1 summarizes the current threshold levels for marine mammals used to analyze explosives identified for use in the Long Range Strike WSEP mission area. The mammal species of interest for Long Range Strike WSEP are spread across four functional hearing groups, three for cetaceans – low frequency (LF), mid frequency (MF) and high frequency (HF) – and one for in-water Phocids.

Table A-1. Explosives Threshold Levels for Marine Mammals

Functional Hearing Group	Mortality*	Level A Harassment			Level B Harassment	
		Slight Lung Injury*	GI Tract Injury	PTS	TTS	Behavioral
LF Cetaceans	$91.4M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/2}$	$39.1M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/2}$	Unweighted SPL: 237 dB re 1 μPa	Weighted SEL: 187 dB re 1 $\mu\text{Pa}^2\cdot\text{s}$	Weighted SEL: 177 dB re 1 $\mu\text{Pa}^2\cdot\text{s}$	Weighted SEL: 167 dB re 1 $\mu\text{Pa}^2\cdot\text{s}$
				Unweighted SPL: 230 dB re 1 μPa	Unweighted SPL: 224 dB re 1 μPa (23 psi PP)	
MF Cetaceans			Unweighted SPL: 237 dB re 1 μPa	Weighted SEL: 187 dB re 1 $\mu\text{Pa}^2\cdot\text{s}$	Weighted SEL: 172 dB re 1 $\mu\text{Pa}^2\cdot\text{s}$	Weighted SEL: 167 dB re 1 $\mu\text{Pa}^2\cdot\text{s}$
				Unweighted SPL: 230 dB re 1 μPa	Unweighted SPL: 224 dB re 1 μPa (23 psi PP)	

Table A-1. Explosives Threshold Levels for Marine Mammals, Cont'd

Functional Hearing Group	Mortality*	Level A Harassment			Level B Harassment	
		Slight Lung Injury*	GI Tract Injury	PTS	TTS	Behavioral
HF Cetaceans			Unweighted SPL: 237 dB re 1 µPa	Weighted SEL: 154 dB re 1 $\mu Pa^2 \cdot s$	Weighted SEL: 139 dB re 1 $\mu Pa^2 \cdot s$	Weighted SEL: 141 dB re 1 $\mu Pa^2 \cdot s$
				Unweighted SPL: 202 dB re 1 µPa	Unweighted SPL: 196 dB re 1 µPa (1 psi PP)	
Phocids (in water)			Unweighted SPL: 237 dB re 1 µPa	Weighted SEL: 192 dB re 1 $\mu Pa^2 \cdot s$	Weighted SEL: 177 dB re 1 $\mu Pa^2 \cdot s$	Weighted SEL: 172 dB re 1 $\mu Pa^2 \cdot s$
				Unweighted SPL: 218 dB re 1 µPa	Unweighted SPL: 212 dB re 1 µPa (6 psi PP)	

M = Animal mass based on species (kilograms); *D* = Water depth (meters); dB re 1 µPa = decibels referenced to 1 microPascal; dB re 1 $\mu Pa^2 \cdot s$ = decibels reference to 1 microPascal-squared – seconds; GI = gastrointestinal; PTS = permanent threshold shift; SEL = sound exposure level; ; TTS = temporary threshold shift; SPL = sound pressure level ; PP = peak pressure
*Expressed in terms of acoustic impulse (Pascal – seconds [Pa·s])

A.1.2.2 Sea Turtles

The weapons impact zone will be located in an area that is inhabited by species listed as threatened or endangered under the ESA (16 USC §§ 1531-1543), including sea turtles. Operation of sound sources, that is, transmission of acoustic signals in the water column, could potentially cause harm or harassment to listed species.

Until recently, there were no acoustic energy or pressure impact thresholds defined specifically for ESA-listed sea turtles, and in the absence of such information the thresholds used for marine mammal analysis were typically applied. However, NMFS has recently undertaken a more detailed investigation of the effects of underwater detonations on turtles and provided the following summary of potential behavioral responses at various peak dB levels (Table A-2).

Table A-2. Range of Sea Turtle Behavioral Responses at Multiple Underwater Noise Levels

dB Level (Peak) Range	Response Category	Number of Animals Potentially Affected
110 – 160	Discountable effects; minor response possible, but within the range of normal behaviors.	Very few
>160 – 200	Some swimming and diving response, becoming stronger and more frequent at higher dB levels.	Few at 160 dB; most at 200 dB
>200 – 220	Strong avoidance response.	Some to all at 220 dB
>220	Intolerable.	All individuals

dB = decibel

Although there has been recent effort to address turtle-specific thresholds, there are currently no experimental or modeling data sufficient to support development of physiological thresholds. However, NMFS has recently endorsed sea turtle criteria and thresholds for impulsive sources (including detonations) to be used in impact analysis. In some cases, turtle-specific data are not available and marine mammal criteria are therefore used. Similar to marine mammal analysis, criteria and thresholds are provided for mortality (extensive lung injury), non-lethal injury (slight lung or GI tract injury), onset of PTS and TTS, and behavioral effects (Finneran and Jenkins, 2012).

Table A-3. Criteria and Thresholds Used for Sea Turtle Exposure Impulsive Impact Analysis

Impulsive Sound Exposure Impact	Threshold Value
Onset Mortality (1% mortality based on extensive lung injury)*	$91.4M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/2}$
Onset Slight Lung Injury*	$39.1M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/2}$
Onset Slight Gastrointestinal Tract Injury	237 dB re 1 µPa SPL (104 psi)
Onset Permanent Threshold Shift	187 dB re 1 µPa^2-s SEL (T^2)
	230 dB re 1 µPa Peak SPL
Onset Temporary Threshold Shift	172 dB re 1 µPa^2-s SEL (T^2)
	224 dB re 1 µPa Peak SPL
Behavioral Effects	175 dB re 1 µPa unweighted RMS

D = depth of animal (meters); dB = decibel; dB re 1 µPa = decibels referenced to 1 micropascal; dB re 1 µPa^2·s = decibels referenced to 1 micropascal-squared second; M = animal mass based on species (kilograms); RMS = root mean square; SEL = sound exposure level; SPL = sound pressure level; T = turtle auditory weighting
*Expressed in terms of acoustic impulse (pascal seconds [Pa-s])

A.2 EXPLOSIVE ACOUSTIC SOURCES

A.2.1 Acoustic Characteristics of Explosive Sources

The acoustic sources to be deployed during Long Range Strike WSEP missions are categorized as broadband explosives. Broadband explosives produce significant acoustic energy across several frequency decades of bandwidth. Propagation loss is sufficiently sensitive to frequency as to require model estimates at several frequencies over such a wide band.

Explosives are impulsive sources that produce a shock wave that dictates additional pressure-related metrics (peak pressure and positive impulse). Detailed descriptions of the sources in the Long Range Strike WSEP mission area are provided in this subsection.

Explosives detonated underwater introduce loud, impulsive, broadband sounds into the marine environment. Three source parameters influence the effect of an explosive: the weight of the explosive material, the type of explosive material, and the detonation depth. The net explosive weight (or NEW) accounts for the first two parameters. The NEW of an explosive is the weight of TNT required to produce an equivalent explosive power.

A.2.2 Animal Harassment Effects of Explosive Sources

The harassments expected to result from these sources are computed on a per event basis, where an event lasts for 24 hours and takes into account multiple explosives that would detonate within that time period. Within that 24-hour time period it is assumed that the animal population remains constant, or in other words, animals exposed to sounds at the beginning of the 24-hour period would also be exposed to any sounds occurring at the end of the period. A new animal population is assumed for each consecutive 24-hour period. In some cases this can be a more conservative approach than assuming each detonation, or burst of detonations, is received by a new population of animals. It is important to note that only energy metrics are affected by the accumulation of energy over a 24-hour period. Pressure metrics (e.g., peak pressure and positive impulse) do not accumulate. Rather, a maximum is taken over all of the detonations specified within the 24-hour period. A more detailed description of pressure and energy considerations resulting from munition bursts is provided in Section A.2.3 below.

Explosives are modeled as detonating at depths ranging from the water surface to 10 feet below the surface, as provided by Government-Furnished Information. Impacts from above surface detonations were considered negligible and not modeled.

For sources that are detonated at shallow depths, it is frequently the case that the explosion may breach the surface with some of the acoustic energy escaping the water column. We model surface detonations as occurring one foot below the water surface. The source levels have not been adjusted for possible venting nor does the subsequent analysis attempt to take this into account.

A.2.3 Zone of Influence: Per-Detonation Versus Net Explosive Weight Combination

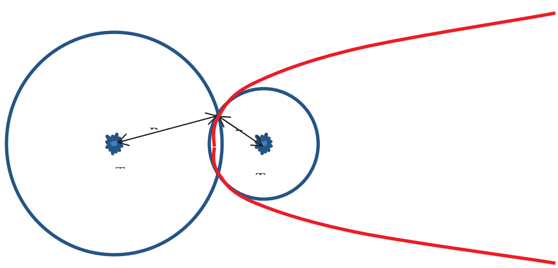
It may be useful to consider why and when it is appropriate to treat rounds within a burst as separate events, rather than combining the net explosive weights of all rounds and treating it as a single, larger event. The basic information necessary to address this issue is provided below, where pressure-based metrics are considered separately from energy-level metrics.

Peak Pressure and Positive Impulse

Peak pressures add if two (or more) impulses reach the same point at the same time. Since explosive rounds go off at different times and locations, this will only be true for a small set of points. This problem is mathematically the same as the passive sonar problem of localizing a sound source based on the time difference of arrival (TDOA) of a signal reaching two receivers (R1 and R2). The red curve in the figure (half of a hyperbola) represents the set of all points where:

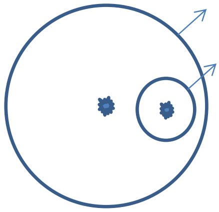
R1 – R2 = c*(T2 – T1), for

c = the speed of sound in water, and



T1 and T2 being the detonation times of the two rounds:

Such a curve can only be drawn when c*(T2-T1) is less than the distance between the two explosions. If, for instance, 30 rounds/second are fired (and the difference in impact time is assumed to be roughly the distance in firing time), then the peak impact pressure from the first round will have traveled 1,500 meters/second * 1/30 second = 50 meters. If the second round hits less than 50 meters from the first round, the impact wave from the second round will never catch the impact wave from the first.



In the first case (loose grouping), the pressures will only add along a curve with very narrow width and negligible volume. The pressure on this curve is less than twice the pressure of the closest round, as it will be the pressure at R2 and at (R2+c*dT). In the second case (tight grouping), the pressures will never add.

If this logic is extended to a many-shot burst, the logic becomes even more persuasive. For the impulse peak from a third shot to interact with the peaks from the first two using the 30 rounds/second assumption, it would have to impact the water more than 100 meters away from the impact of the first round and more than 50 meters away from the impact of the second round. Even in that case, there would be at most two places in the ocean where the curve from the 1st and 3rd impacts would meet the curve from 2nd and 3rd explosions (and the travel distances would have to be 50 meters longer for one and 100 meters longer for the other). In summary:

- There would be 0 to 4 directions where a curve (a hyperbola approaches an asymptotic line far from the source) of negligible thickness, and volume would have less than two times the pressure from the closest source
- There would be 0 to 2 very small points with no extent in range or bearing where one would see less than three times the pressure from the closest source
- In every other part of the ZOI, the impulse from each round would be received separately by any animal present

For the 4th round and any subsequent round, another curve could be added, if it was far enough away from the previous shots so that their peak had not already passed the impact point. However, this new curve would intersect with the previous 2 curves at a different location than where the first two curves intersected. No matter how many rounds are fired, there would not be any point in the ocean where more than 3 peaks arrive at the same time. These points would have almost no volumetric extent and required range increases from the closest source of N*dt*c, where N is the difference in shot number and dt is the time between shots.

If the rate of fire is increased, there is a decrease in the additional required separation in order to have any coherent increase in pressure or positive impulse. However, the end result is that almost all of the ocean experiences only one pressure peak at a time.

If the rounds are far enough apart in space and close enough in time, there will be curves where sequential rounds add coherently; however,

- They will not occupy any significant volume, and
- They will be less than a factor of 2 above the pressure or positive impulse of the nearest source.

Contrast this with the alternative assumption that pressures from separate rounds be added. This models the event as if all rounds went of exactly at the same place and exactly at the same time. That is the only way that travelling pressure peaks from separate rounds would go through space together and add pressures at all points. This is not realistic and would over-estimate pressure and positive impulse metrics by a factor equal to the number of rounds in the burst, which could be 10 or 20 dB in pressure levels.

Energy Metrics

Energy metrics accumulate the integral of the power density of each explosion over the duration of the impulse. Thus, even though the peaks from separate explosions arrive at different times, the energy from all of their arrivals will be added. If you fire a number of rounds close together in a burst (N_{burst}), the energy from all of the rounds will add and the sound exposure level will be 10*log10(N_{burst}) higher than if a single shot had been fired. The area affected, A_{burst}, would be larger than the area affected by a single shot (A_1), because additional transmission loss would be needed to reduce the larger energy level to a given threshold.

The alternative assumption is that each round sees a fresh population and the area affected by N single bullets is $N*A_1$. The single-shot assumption is more conservative as long as $A_{burst} < N*A_1$.

A.3 ENVIRONMENTAL CHARACTERIZATION

A.3.1 Important Environmental Parameters for Estimating Animal Harassment

Propagation loss ultimately determines the extent of the ZOI for a particular source activity. In turn, propagation loss as a function of range depends on a number of environmental parameters including:

- Water depth;
- Sound speed variability throughout the water column;
- Bottom geo-acoustic properties; and
- Surface roughness, as determined by wind speed.

Due to the importance that propagation loss plays in Anti-Submarine Warfare, the Navy has, over the last four to five decades, invested heavily in measuring and modeling these environmental parameters. The result of this effort is the following collection of global databases containing these environmental parameters, which are accepted as standards for Navy modeling efforts. Table A-4 contains the version of the databases used in the modeling for this report.

Table A-4. Navy Standard Databases Used in Modeling

Parameter	Database	Version
Water Depth	Digital Bathymetry Data Base Variable Resolution	DBDBV 6.0
Ocean Sediment	Re-packed Bottom Sediment Type	BST 2.0
Wind Speed	Surface Marine Gridded Climatology Database	SMGC 2.0
Temperature/Salinity Profiles	Generalized Digital Environment Model	GDEM 3.0

The sound speed profile directs the sound propagation in the water column. The spatial variability of the sound speed field is generally small over operating areas of typical size. The presence of a strong oceanographic front is a noteworthy exception to this rule. To a lesser extent, variability in the depth and strength of a surface duct can be of some importance. If the sound speed minimum occurs within the water column, more sound energy can travel further without suffering as much loss (ducted propagation). But if the sound speed minimum occurs at the surface or bottom, the propagating sound interacts more with these boundaries and may become attenuated more quickly. In the mid-latitudes, seasonal variation often provides the most significant variation in the sound speed field. For this reason, both summer and winter profiles are modeled to demonstrate the extent of the difference.

Losses of propagating sound energy occur at the boundaries. The water-sediment boundary defined by the bathymetry can vary by a large amount. In a deep water environment, the interaction with the bottom may matter very little. In a shallow water environment the opposite is true and the properties of the sediment become very important. The sound propagates through the sediment, as well as being reflected by the interface. Soft (low density) sediment behaves more like water for lower frequencies and the sound has relatively more transmission and relatively less reflection than a hard (high density) bottom or thin sediment.

The roughness of the boundary at the water surface depends on the wind speed. Average wind speed can vary seasonally, but could also be the result of local weather. A rough surface scatters the sound energy and increases the transmission loss. Boundary losses affect higher frequency sound energy much more than lower frequencies.

A.3.2 Characterizing the Acoustic Marine Environment

The environment for modeling impact value is characterized by a frequency-dependent bottom definition, range-dependent bathymetry and sound velocity profiles (SVP), and seasonally varying wind speeds and SVPs. The bathymetry database is on a grid of variable resolution.

The SVP database has a fixed spatial resolution storing temperature and salinity as a function of time and location. The low frequency bottom loss is characterized by standard definition of geo-acoustic parameters for the given sediment type for the area. The high frequency bottom loss class is fixed to match expected loss for the sediment type. The area of interest can be characterized by the appropriate sound speed profiles, set of low frequency bottom loss parameters, high frequency bottom loss class, and HFEVA very-high frequency sediment type for modeled frequencies in excess of 10 kiloHertz (kHz).

Generally seasonal variation is sampled by looking at summer and winter cases that tend to capture extremes in both the environmental variability as well as animal populations. Calculations were made for both seasons even though events are expected to be at the end of the summer season.

Impact volumes in the operating area are then computed using propagation loss estimates and the explosives model derived for the representative environment.

A.3.3 Description of the BSURE Training Range Area Environment

The Long Range Strike mission area is located to the northwest of the Hawaiian island of Kauai, in the northern part of the BSURE tracking range. The bottom is characterized as clay according to the Bottom Sediments Type Database. Environmental values were extracted from unclassified Navy standard databases in a radius of 75 kilometers around the center point at

N 22° 50.0' W 160° 00'

The Navy standard database for bathymetry has a resolution of 0.05 minutes in the Pacific Ocean; see Figure A-1. Mean and median depths from DBDBV in the extracted area are 4,351 and 4,550 meters, respectively. Minimum and maximum depths are 1,135 and 4,848 meters, respectively.

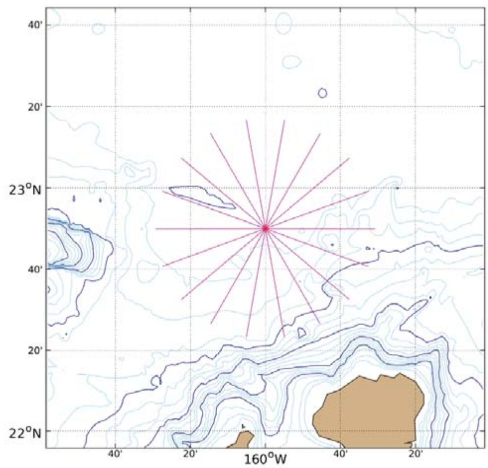


Figure A-1. Bathymetry (in 250-meter contours) for the BSURE Range and Long Range Strike WSEP mission area.

The seasonal variability in wind speed was modeled as 7.7 knots in the summer and 7.1 knots in the winter.

Example input of range-dependent bathymetry is depicted in Figure A-2 for the due-north bearing.

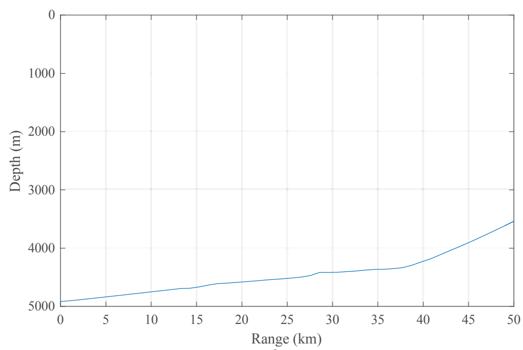


Figure A-2. Bathymetry along 150° radial to the SW from center point

A.4 MODELING IMPACT ON MARINE ANIMALS

Many underwater actions include the potential to injure or harass marine animals in the neighboring waters through noise emissions. The number of animals exposed to potential harassment in any such action is dictated by the propagation field and the characteristics of the noise source.

Estimating the number of animals that may be injured or otherwise harassed in a particular environment entails the following steps.

- For the relevant environmental acoustic parameters, transmission loss (TL) estimates are computed, sampling the water column over the appropriate depth and range intervals. TL calculations are also made over disjoint one-third octave bands for a wide range of frequencies with dependence in range, depth, and azimuth for bathymetry and sound speed. TL computations were sampled with 40 degree spacing in azimuth.
- The Type II weighted total accumulated energy within the waters where the source detonates is sampled over a volumetric grid. At each grid point, the received energy from each source emission is modeled as the effective energy source level reduced by the appropriate propagation loss from the location of the source at the time of the emission to that grid point and summed. For the peak pressure or positive impulse, the appropriate metric is similarly modeled for each emission. The maximum value of that metric over all frequencies and emissions, is stored at each grid point.
- The impact volume for a given threshold is estimated by summing the incremental volumes represented by each grid point sampled in range and depth for which the appropriate metric exceeds that threshold, and accumulated over all modeled bearings. Histograms representing impact volumes as a function of (possibly depth-dependent) thresholds, are stored in a spreadsheet for dynamic changes of thresholds.
- Finally, the number of harassments is estimated as the inner-product of the animal density depth profile and the impact volume and scaled by user-specifiable surface animal densities.

This section describes in detail the process of computing impact volumes.

A.4.1 Calculating Transmission Loss

Transmission loss (TL) was pre-computed for both seasons for thirty non-overlapping frequency bands. The 30 bands had one-third octave spacing around center frequencies from 50 Hertz (Hz) to approximately 40.637 kHz. In the previous report, TL was computed at only seven frequencies. The broadband nature of the sources has been well covered in this report. The TL was modeled using the Navy Standard GRAB V3 propagation loss model (Keenan, 2000) with CASS v4.3. GRAB is well suited to modeling transmission losses over the wide frequency band of interest.

The TL results were interpolated onto a variable range grid with logarithmic spacing. The increased spatial resolution near the source provided greater fidelity for estimates.

The TL was calculated from the source depth to an array of output depths. The output depths were the mid-points of depth intervals matching GDEM's depth sampling. For water depths from surface to 10 meter depth, the depth interval was 2 meters. Between 10 meters and 100 meters water depth, the depth interval was 5 meters. For waters greater than 100 meters, the depth interval was 10 meters. For the BSURE area environment, there were forty-five depth bins spanning 0 to 1000 meters. The output depths represent possible locations of the animals and are used with the animal depth distribution to better estimate animal impact. The depth grid is used to make the surface image interference correction and to capture the depth-dependence of the positive impulse threshold.

A.4.2 Computing Impact Volumes

This section and the next provide a detailed description of the approach taken to compute impact volumes for explosives. The impact volume associated with a particular activity is defined as the volume of water in which some acoustic metric exceeds a specified threshold. The product of this impact volume with a volumetric animal density yields the expected value of the number of animals exposed to that acoustic metric at a level that exceeds the threshold. The acoustic metric can either be an energy term (weighted or un-weighted energy flux density, either in a limited frequency band or across the full band) or a pressure term (such as peak pressure or positive impulse). The thresholds associated with each of these metrics define the levels at which half of the animals exposed will experience some degree of harassment (ranging from behavioral change to mortality).

Impact volume is particularly relevant when trying to estimate the effect of repeated source emissions separated in either time or space. Impact range, which is defined as the maximum range at which a particular threshold is exceeded either for a single source emission or accumulation of source emissions over a 24-hour period, defines the range to which marine mammal activity is monitored in order to meet mitigation requirements. Based on the latest guidance, this impact range is also used to provide conservative two-dimensional calculations of the exposure estimates by multiplying the impact area by the animal density and the total number of events proposed each year. Refer to Section A.5.3.

The effective energy source level is modeled directly for the sources to be used at the BT-9 target area. The energy source level is comparable to the model used for other explosives (Arons (1954), Weston (1960), McGrath (1971), Urick (1983), Christian and Gaspin (1974)). The energy source level over a one-third octave band with a center frequency of *f* for a source with a net explosive weight of *w* pounds is given by:

$$\text{ESL} = 10 \log_{10} (0.26\, f) + 10 \log_{10} (2\, p_{max}{}^{2} / [1/\theta^{2} + 4\, \pi^{2} f^{2}]) + 197 \text{ dB}$$

where the peak pressure for the shock wave at 1 meter is defined as

$$p_{max} = 21600\, (w^{1/3} / 3.28)^{1.13} \text{ psi} \qquad \text{(B-1)}$$

and the time constant is defined as:

$$\theta = [(0.058)\, (w^{1/3})\, (3.28 / w^{1/3})^{0.22}] / 1000 \text{ sec} \qquad \text{(B-2)}$$

For each explosive source, the amount of acoustic energy injected into the water column is calculated, conservatively assuming that all explosive energy is converted into acoustic energy. The propagation loss for each frequency, expressed as a pressure term, modulates the sound energy found at each point on the grid of depth (uniform spacing) and range (logarithmic spacing). If a threshold is exceeded at a point, the impact volume at an annular sector is added to the total impact volume. The impact volume at a point is calculated exactly using the depth, range and azimuthal intervals associated with that particular point in the water column.

A.4.3 Effects of Metrics on Impact Volumes

The impact of explosive sources on marine wildlife is measured by three different metrics, each with its own thresholds. The energy metric, the peak pressure metric, and the "modified" positive impulse metric are discussed in this section. The energy metric, using the Type II weighted total energy, is accumulated after the explosive detonation. The other two metrics, peak pressure and positive impulse, are not accumulated but rather the maximum levels are taken.

Energy Metric

The energy flux density is sampled at several frequencies in one-third-octave bands. The total weighted energy flux at each range/depth combination is obtained by summing the product of the Type II frequency weighting function, $W_{II}(f)$, and the energy flux density at each frequency. The type II weighting function in dB is given by:

$$W_{II}(f) = maximum\left(G_1(f), G_{12}(f)\right), \text{ where}$$
$$G_1(f) = K_1 + 20log_{10}\left[\frac{b_1^2 f^2}{(a_1^2+f^2)(b_1^2+f^2)}\right], \text{ and}$$
$$G_2(f) = K_2 + 20log_{10}\left[\frac{b_2^2 f^2}{(a_2^2+f^2)(b_2^2+f^2)}\right].$$

The component lower cutoff frequencies, a_1 and a_2, upper cutoff frequencies, b_1 and b_2, and gains, K_1 and K_2, are a function of the functional hearing group. Parameters used for cetaceans are given in Table A-5.

Table A-5. Type II Weighting Parameters used for Cetaceans

Functional Hearing Group	K_1(dB)	a_1(Hz)	b_1(Hz)	K_2(dB)	a_2(Hz)	b_2(Hz)
LF cetaceans	-16.5	7	22,000	0.9	674	12,130
MF cetaceans	-16.5	150	160,000	1.4	7,829	95,520
HF cetaceans	-19.4	200	180,000	1.4	9,480	108,820

Note that because the weightings are in dB, we will actually weight each frequency's EFD by $10^{(W_{II}(f)/10)}$, sum the EFDs over frequency and then convert the weighted total energy to back to dB, with level = 10 $\log_{10}$(total weighted EFD).

Phocids and sea turtles use a simpler, Type I, weighting function to represent their hearing sensitivities. The weighting function is the same as that given above for G_1, with K_1 set to zero and a_1 and b_1 given below in Table A-6.

Table A-6. Type I Weighting Parameters for Phocids and Sea Turtles

Functional Hearing Group	a(Hz)	b(Hz)
Phocids (In-Water)	75	75,000
Sea Turtles	75	2,000

Peak Pressure Metric

The peak pressure metric is a simple, straightforward calculation at each range/animal depth combination. First, the transmission pressure ratio, modified by the source level in a one-third-octave band, is summed across frequency. This averaged transmission ratio is normalized by the total broadband source level. Peak pressure at that range/animal depth combination is then simply the product of:

- The square root of the normalized transmission ratio of the peak arrival,
- The peak pressure at a range of 1 meter (given by equation B-1), and
- The similitude correction (given by $r^{-0.13}$, where r is the slant range).

If the peak pressure for a given grid point is greater than the specified threshold, then the incremental volume for the grid point is added to the impact volume for that depth layer.

"Modified" Positive Impulse Metric

The modeling of positive impulse follows the work of Goertner (Goertner, 1982). The Goertner model defines a "partial" impulse as

$$I = \int_0^{T_{min}} p(t)dt \,,$$

where $p(t)$ is the pressure wave from the explosive as a function of time t, defined so that $p(t) = 0$ for $t <$ 0. This similitude pressure wave is modeled as

$$p(t) = p_{max}\, e^{-t/\theta}$$

where p_{max} is the peak pressure at 1 meter (see, equation B-1), and θ is the time constant defined in equation A-2.

The upper limit of the "partial" impulse integral is

$$T_{min} = \min\,\{T_{cut}, T_{osc}\}$$

where T_{cut} is the time to cutoff and T_{osc} is a function of the animal lung oscillation period. When the upper limit is T_{cut}, the integral is the definition of positive impulse. When the upper limit is defined by T_{osc}, the integral is smaller than the positive impulse and thus is just a "partial" impulse. Switching the integral limit from T_{cut} to T_{osc} accounts for the diminished impact of the positive impulse upon the animals lungs that compress with increasing depth and leads to what is sometimes call a "modified" positive impulse metric.

The time to cutoff is modeled as the difference in travel time between the direct path and the surface-reflected path in an isovelocity environment. At a range of r, the time to cutoff for a source depth z_s and an animal depth z_a is

$$T_{cut} = 1/c\ \{\ [r^2 + (z_a + z_s)^2]^{1/2} - [r^2 + (z_a - z_s)^2]^{1/2}\ \}$$

where c is the speed of sound.

The animal lung oscillation period is a function of animal mass M and depth z_a and is modeled as

$$T_{osc} = 1.17\ M^{1/3}\ (1 + z_a/33)^{-5/6}$$

where M is the animal mass (in kg) and z_a is the animal depth (in feet).

The modified positive impulse threshold is unique among the various injury and harassment metrics in that it is a function of depth and the animal weight. So instead of the user specifying the threshold, it is computed as $K\,(M)^{1/3}\,(1 + z_a/33)^{1/2}$. The coefficient K depends upon the level of exposure. For the onset of slight lung injury, K is 39.1; for the onset of extensive lung hemorrhaging (1% mortality), K is 91.4.

Although the thresholds are a function of depth and animal weight, sometimes they are summarized as their value at the sea surface for a typical dolphin calf (with an average mass of 12.2 kg). For the onset of slight lung injury, the threshold at the surface is approximately 13 psi-msec; for the onset of extensive lung hemorrhaging (1% mortality), the threshold at the surface is approximately 31 psi-msec.

As with peak pressure, the "modified" positive impulse at each grid point is compared to the derived threshold. If the impulse is greater than that threshold, then the incremental volume for the grid point is added to the impact volume for that depth layer.

A.5 ESTIMATING ANIMAL HARASSMENT

A.5.1 Distribution of Animals in the Environment

Species densities are usually reported by marine biologists as animals per square kilometer. This gives an estimate of the number of animals below the surface in a certain area, but does not provide any information about their distribution in depth. The impact volume vector specifies the volume of water ensonified above the specified threshold in each depth interval. A corresponding animal density for each of those depth intervals is required to compute the expected value of the number of exposures. The two-dimensional area densities do not contain this information, so three-dimensional densities must be constructed by using animal depth distributions to extrapolate the density at each depth.

The following bottlenose dolphin (summer profile) example demonstrates the method used to account for three-dimensional analysis by merging the depth distributions with user-specifiable surface densities. Bottlenose dolphins are distributed with:

- 19.2% in 0-10 meters,
- 76.8% in 10-50 meters,
- 1.7% in 50-100 meters, and
- 2.3% in 100-165 meters.

The impact volume vector is sampled at 30 depths over the maximally 165 meter water column. Since this is a finer resolution than the depth distribution, densities are apportioned uniformly over depth intervals. For example, 19.2% of bottlenose dolphins are in the 0-10 meter interval, so approximately

- 3.84% are in 0-2 meters,
- 3.84% are in 2-4 meters,
- 3.84% are in 4-6 meters,
- 3.84% are in 6-8 meters, and
- 3.84% are in 8-10 meters.

Similarly, 76.8% are in the 10-50 m interval, so approximately

- 9.60% are in 10 - 15 meters,
- 9.60% are in 15 - 20 meters,
- 9.60% are in 20 - 25 meters,
- etc.

The animal densities and depth distributions used in this study are provided in Appendix B.

A.5.2 Harassment Estimates

Impact volumes for all depth intervals are scaled by their respective depth densities, divided by their depth interval widths, summed over the entire water column and finally converted to square kilometers to create impact areas. The spreadsheet allows a user-specifiable surface density in animals per square kilometer, so the product of these quantities yields expected number of animals in ensonified water where they could experience harassment.

Since the impact volume vector is the volume of water at or above a given threshold per unit operation (e.g. per detonation, or clusters of munitions explosions), the final harassment count for each animal is the unit operation harassment count multiplied by the number of units deployed.

The detonations of explosive sources are generally widely spaced in time and/or space. This implies that the impact volume for multiple firings can be easily derived by scaling the impact volume for a single detonation. Thus the typical impact volume vector for an explosive source is presented on a per-detonation basis.

A.5.3 "Two-Dimensional" Harassment Estimates

If one does not have confidence in the depth-distribution of animals within the water column, then a more conservative approach to estimating harassment is to compute only a two-dimensional impact. In this approach, the impact volume is essentially a cylinder extending from the surface to the seafloor, centered at the sound source and with a radius set equal to the maximum range, R_{max}, across all depths and azimuths at which the particular metric level is still above threshold. The number of animals impacted is computed simply by multiplying the area of a circle with radius R_{max}, by the original animal density given in animals per square kilometer. Impacts computed in this manner will always exceed or equal impacts based on depth-dependent animal distributions.

A.6 REFERENCES

Arons, A. B., 1954. "Underwater Explosion Shock Wave Parameters at Large Distances from the Charge," J. *Acoust. Soc. Am*. 26, 343.

Bartberger, C. L., 1965. "Lecture Notes on Underwater Acoustics," NADC Report NADC=WR-6509, Naval Air Development Center Technical Report, Johnsville, PA, 17 May (AD 468 869) (UNCLASSIFIED).

Christian, E. A. and J. B. Gaspin, 1974. Swimmer Safe Standoffs from Underwater Explosions," NSAP Project PHP-11-73, Naval Ordnance Laboratory, Report NOLX-89, 1 July (UNCLASSIFIED).

Department of the Navy, 1998. "Final Environmental Impact Statement, Shock Testing the SEAWOLF Submarine," U.S. Department of the Navy, Southern Division, Naval Facilities Engineering Command, North Charleston, SC, 637 p.

Department of the Navy, 2001. "Final Environmental Impact Statement, Shock Trial of the WINSTON S. CHURCHILL (DDG 81)," U.S. Department of the Navy, NAVSEA, 597 p.

DeRuiter, S. L., and K. L. Doukara, 2012. Loggerhead turtles dive in response to airgun sound exposure. *Endangered Species Research*, Volume 16:55-63. January 18, 2012.

Finneran, J. J., R. Dear, D. A. Carder, and S. H. Ridgway, 2002. Temporary shift in masked hearing thresholds in odontocetes after exposure to single underwater impulses from a seismic watergun. *Journal of the Acoustical Society of America*. 111:2929-2940.

Finneran, J. J., and C. E. Schlundt, 2004. Effects of intense pure tones on the behavior of trained odontocetes. Space and Naval Warfare Systems Center, San Diego, Technical Document. September.

Finneran, J. J., D. A. Carder, C.E. Schlundt and S.H. Ridgway. 2005. Temporary threshold shift in bottlenose dolphins (Tursiops truncatus) exposed to mid-frequency tones. *Journal of Acoustical Society of America*. 118:2696-2705.

Finneran, J. J., and A. K. Jenkins, 2012. Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis. U.S. Navy, SPAWAR Systems Center. April 2012.

Goertner, J. F., 1982. "Prediction of Underwater Explosion Safe Ranges for Sea Mammals," NSWC TR 82-188, Naval Surface Weapons Center, Dahlgren, VA.

Keenan, R. E., D. Brown, E. McCarthy, H. Weinberg, and F. Aidala, 2000. "Software Design Description for the Comprehensive Acoustic System Simulation (CASS Version 3.0) with the Gaussian Ray Bundle Model (GRAB Version 2.0)", NUWC-NPT Technical Document 11,231, Naval Undersea Warfare Center Division, Newport, RI, 1 June (UNCLASSIFIED).

Ketten, D. R., 1998. Marine mammal auditory systems: A summary of audiometric and anatomical data and its implications for underwater acoustic impacts. NOAA-TM-NMFS-SWFSC-256, Department of Commerce.

Kryter, K. D. W. D. Ward, J. D. Miller, and D. H. Eldredge, 1966. Hazardous exposure to intermittent and steady-state noise. *Journal of the Acoustical Society of America*. 48:513-523.

McCauley, R. D., J. Fewtrell, A. J. Duncan, C. Jenner, M.-N. Jenner, J. D. Penrose, R. I. T. Prince, A. Adhitya, J. Murdoch, and K. McCabe, 2000. *Marine seismic surveys: analysis and propagation of air-gun signals; and effects of air-gun exposure on humpback whales, sea turtles, fishes and squid*. CMST 163, Report R99-15, prepared for the Australian Petroleum Production Exploration Association from the Centre for Marine Science and Technology, Curtin University, Perth, Western Australia.

McGrath, J. R., 1971. "Scaling Laws for Underwater Exploding Wires," *J. Acoust. Soc. Am*., 50, 1030-1033 (UNCLASSIFIED).

Miller, J. D., 1974. Effects of noise on people. *Journal of the Acoustical Society of America*. 56:729–764.

Nachtigall, P. E., J. L. Pawloski, and W. W. L. Au, 2003. Temporary threshold shift and recovery following noise exposure in the Atlantic bottlenose dolphin (Tursiops truncatus). *Journal of the Acoustical Society of America*, 113:3425-3429.

NOAA, 2015. "DRAFT Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing," Revised version for Second Public Comment Period, 180 p.

Richmond, D. R., J. T. Yelverton, and E. R. Fletcher, 1973. "Far-field underwater-blast injuries produced by small charges," DNA 3081T. Lovelace Foundation for Medical Education and Research, Defense Nuclear Agency: Washington, D.C.

Schlundt, C. E., J. J. Finneran, D. A. Carder, and S. H. Ridgway, 2000. Temporary shift in masked hearing thresholds of bottlenose dolphins, Tursiops truncatus, nd white whales, Delphinapterous leucas, after exposure to intense tones. *Journal of the Acoustical Society of America*. 107:3496-3508.

Southall, B. L., Bowles, A. E., Ellison, W. T., Finneran, J. J., Gentry, R. L., Greene, C. R., Jr., Kastak, D., Ketten, D. R., Miller, J. H., Nachtigall, P. E., Richardson, W. J., Thomas, J. A., and Tyack, P. L., 2007. "Marine mammal noise exposure criteria: initial scientific recommendations," *Aquatic Mammals*, 33, 411-521.

Urick, R. J., 1983. Principles of Underwater Sound for Engineers, McGraw-Hill, NY (first edition: 1967, second edition: 1975, third edition: 1983) (UNCLASSIFIED).

Ward, W. D., 1997. Effects of high-intensity sound. In Encyclopedia of Acoustics, ed. M.J. Crocker, 1497-1507. New York: Wiley.

Weston, D. E., 1960. "Underwater Explosions as Acoustic Sources," *Proc. Phys. Soc*., 76, 233 (UNCLASSIFIED).

Yelverton, J. T., 1981. Underwater Explosion Damage Risk Criteria for Fish, Birds, and Mammals, Manuscript, presented at 102nd Meeting of the Acoustical Society of America, Miami Beach, FL, December, 1982. 32pp.

APPENDIX B

MARINE SPECIES DEPTH DISTRIBUTIONS

This page is intentionally blank.

MARINE SPECIES DEPTH DISTRIBUTIONS USED IN ACOUSTIC MODELING

Source: Watwood, S. L., and D. M. Buonantony, 2012. Dive Distribution and Group Size Parameters for Marine Species Occurring in Navy Training and Testing Areas in the North Atlantic and North Pacific Oceans. NUWC-NPT Technical Document 12,085. 12 March 2012.

Table B-1. Marine Mammals Depth Distributions Used in Acoustic Modeling

Species	Depth Category (m = meters)	Percentage of Time at Depth
Humpback whale	0 – 10 m	39.55
	10 – 20 m	26.51%
	20 – 30 m	11.66%
	30 – 40 m	4.25%
	40 – 50 m	3.04%
	50 – 60 m	2.47%
	60 – 70 m	2.14%
	70 – 80 m	1.66%
	80 – 90 m	1.97%
	90 – 100 m	1.55%
	100 – 110 m	1.39%
	110 – 120 m	1.31%
	120 – 130 m	0.92%
	130 – 140 m	0.72%
	140 – 150 m	0.20%
	150 – 160 m	0.23%
	160 – 170 m	0.15%
	170 – 180 m	0.09%
Blue whale	0 – 15 m	43.078%
	15 – 30 m	29.621%
	30 – 45 m	9.376%
	45 – 60 m	2.334%
	60 – 75 m	2.342%
	75 – 90 m	2.341%
	90 – 105 m	2.264%
	105 – 120 m	2.094%
	120 – 135 m	1.859%
	135 – 150 m	1.528%
	150 – 165 m	1.187%
	165 – 180 m	0.819%
	180 – 195 m	0.532%
	195 – 210 m	0.312%
	210 – 225 m	0.172%
	225 – 240 m	0.084%
	240 – 255 m	0.035%
	255 – 270 m	0.013%
	270 – 285 m	0.005%
	285 – 300 m	0.002%
	300 – 315 m	0.001%

Table B-1. Marine Mammals Depth Distributions Used in Acoustic Modeling, Cont'd

Species	Depth Category (m = meters)	Percentage of Time at Depth
Fin whale	0 – 15 m	46.460%
	15 – 30 m	10.738%
	30 – 45 m	9.105%
	45 – 60 m	4.033%
	60 – 75 m	2.684%
	75 – 90 m	2.466%
	90 – 105 m	2.231%
	105 – 120 m	2.148%
	120 – 135 m	1.947%
	135 – 150 m	1.762%
	150 – 165 m	1.633%
	165 – 180 m	1.592%
	180 – 195 m	1.712%
	195 – 210 m	2.107%
	210 – 225 m	2.663%
	225 – 240 m	2.834%
	240 – 255 m	2.217%
	255 – 270 m	1.125%
	270 – 285 m	0.361%
	285 – 300 m	0.081%
	300 – 315 m	0.011%
	315 – 330 m	0.001%
Sei whale	0 – 40 m	84.50%
	40 – 292 m	15.30%
Sperm whale	0 – 50 m	30.689%
	50 – 100 m	3.220%
	100 – 150 m	3.372%
	150 – 200 m	3.587%
	200 – 250 m	3.757%
	250 – 300 m	3.893%
	300 – 350 m	4.057%
	350 – 400 m	4.434%
	400 – 450 m	4.668%
	450 – 500 m	5.167%
	500– 550 m	4.750%
	550 – 600 m	4.024%
	600 – 650 m	3.537%
	650 – 700 m	3.112%
	700 – 750 m	2.786%
	750 – 800 m	2.461%
	800 – 850 m	2.149%
	850 – 900 m	1.836%
	900 – 950 m	1.563%
	950 – 1000 m	1.316%
	100 – 1050 m	1.098%
	1050 – 1100 m	0.892%
	1100 – 1150 m	0.712%
	1150 – 1200 m	0.581%

Table B-1. Marine Mammals Depth Distributions Used in Acoustic Modeling, Cont'd

Species	Depth Category (m = meters)	Percentage of Time at Depth
	1200 – 1250 m	0.472%
	1250 – 1300 m	0.382%
	1300 – 1350 m	0.306%
	1350 – 1400 m	0.248%
	1400 – 1450 m	0.194%
	1450 – 1500 m	0.161%
	1500 – 1550 m	0.128%
	1550 – 1600 m	0.110%
	1600 – 1650 m	0.086%
	1650 – 1700 m	0.069%
	1700 – 1750 m	0.051%
	1570 – 1800 m	0.039%
	1800 – 1850 m	0.028%
	1850 – 1900 m	0.019%
	1900 – 1950 m	0.013%
	1950 – 2000 m	0.009%
	2000 – 2050 m	0.006%
	2050 – 2100 m	0.004%
	2100 – 2150 m	0.003%
	2150 – 2200 m	0.002%
	2200 – 2250 m	0.002%
	2250 – 2300 m	0.002%
	2300 – 2350 m	0.001%
	2350 – 2400 m	0.001%
Hawaiian monk seal	0 – 4 m	33.00%
	4 – 20 m	34.70%
	20 – 40 m	13.20%
	40 – 60 m	5.50%
	60 – 80 m	3.60%
	70 – 100 m	2.10%
	100 – 120 m	2.50%
	120 – 140 m	2.00%
	140 – 160 m	0.80%
	160 – 180 m	0.70%
	180 – 200 m	0.30%
	200 – 250 m	0.40%
	250 – 350 m	0.90%
	350 – 500 m	0.60%

Table B-2. Sea Turtles Depth Distributions Used in Acoustic Modeling

Species	Depth Category (m = meters)	Percentage of Time at Depth
Green sea turtle	0 – 5 m	59.23%
	6 – 10 m	16.98%
	11 – 15 m	11.68%
	16 – 20 m	6.78%
	21 – 25 m	2.61%

Table B-2. Sea Turtles Depth Distributions Used in Acoustic Modeling, Cont'd

Species	Depth Category (m = meters)	Percentage of Time at Depth
	26 – 30 m	1.39%
	31 – 35 m	0.73%
	36 – 40 m	0.26%
	41 – 45 m	0.06%
	45 – 138 m	0.28 5
Hawksbill sea turtle	0 – 2 m	11.31%
	3 – 10 m	66.25%
	11 – 20 m	11.49%
	21 – 30 m	4.68%
	31 – 40 m	3.59%
	41 – 50 m	2.04%
	51 – 91 m	0.65%
Loggerhead sea turtle	0 – 1 m	19.25%
	2 – 5 m	43.75%
	6 – 10 m	13%
	11 – 15 m	9%
	16 – 20 m	9%
	21 – 25 m	3%
	26 – 30 m	1.25%
	31 – 40 m	0.25%
	41 – 50 m	0.25%
	51 – 60 m	0.25%
	61 – 80 m	0.25%
	81 – 100 m	0.25%
	101 – 150 m	0.25%
	150 – 233 m	0.25%
Olive ridley sea turtle	0 – 1 m	20%
	1 – 10 m	5%
	11 – 20 m	8.50%
	21 – 30 m	14%
	31 – 40 m	13.50%
	41 – 50 m	10%
	51 – 60 m	7%
	61 – 70 m	5.50%
	71 – 80 m	4.50%
	81 – 90 m	3%
	91 – 100 m	2.50%
	101 – 110 m	1.50%
	111 – 120 m	1%
	121 – 130 m	1.50%
	131 – 140 m	0.50%
	141 – 150 m	1%
	151 – 288 m	1%
Leatherback sea turtle	0 – 10 m	18.928%
	11 – 100 m	65.264%
	101 – 200 m	15.626%
	201 – 300 m	0.818%
	301 – 400 m	0.119%

Table B-2. Sea Turtles Depth Distributions Used in Acoustic Modeling, Cont'd

Species	Depth Category (m = meters)	Percentage of Time at Depth
	401 – 500 m	0.103%
	501 – 600 m	0.069%
	601 – 700 m	0.023%
	701 – 800 m	0.015%
	801 – 900 m	0.015%
	901 – 1000 m	0.008%
	1001 – 1100 m	0.004%
	1101 – 1200 m	0.000%
	1201 – 1280 m	0.008%

This page is intentionally blank.

NMFS Response Letter to the BA (July 1, 2016)

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Silver Spring, MD 20910

JUL - 1 2016

Mr. Michael Ackerman
Program Manager, NEPA Division (AFCEC/CZN)
Department of the Air Force
Air Force Civil Engineer Center
2261 Hughes Ave., Ste. 155
JBSA Lackland, TX 78236-9853

Re: ESA section 7 initiation of Formal Consultation on the Air Force's Long Range Strike Weapon Systems Evaluation Program [FPR-2016-9160]

Dear Mr. Ackerman:

This letter acknowledges the National Marine Fisheries Service's (NMFS) receipt of your June 16, 2016, request for formal consultation on the Air Force's Long Range Strike Weapon Systems Evaluation Program for missions from 2016 thru 2021 pursuant to section 7(a)(2) of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1536(a)(2)). Your request was accompanied by a biological assessment and two appendices, one containing acoustic modelling methodology and the other containing marine species depth distribution data. Following initial review of the submittal, we determined there is sufficient information in the submittal package to initiate formal ESA section 7 consultation.

National Marine Fisheries Service (NMFS) is aware that the Air Force is pursuing authorization under the Marine Mammal Protection Act (MMPA) for the take of marine mammals incidental to the Air Force's activities. The incidental take authorization pursuant to the MMPA is a Federal action that is interrelated and interdependent with the Air Force's proposed action. As such, ESA section 7 consultation with the Air Force for activities proposed in 2017 through 2021 will require information on the proposed MMPA incidental take authorizations from NMFS Permits and Conservation Division to complete our analysis and prepare a biological opinion. The statutory timeline for consultations under section 7 of the ESA is 90 days to conduct the consultation and 45 days to complete the biological opinion for a total of 135 days. Considering the information we require to complete our analysis and biological opinion on activities proposed for 2017 through 2021 and the limited amount of time between the Air Force's request for initiation of formal consultation and proposed 2016 activities in early September (i.e., 76 days), we will not be able to complete a formal programmatic biological opinion on all activities proposed by the Air Force before September 1, 2016.

Therefore, we will complete two biological opinions on the Air Force's proposed action. For activities proposed in 2016, which are smaller in scope than the activities that will start in 2017, we plan to finalize our biological opinion on or before August 29, 2016. For activities proposed from 2017 through 2021, we plan to finalize our biological opinion on or before July 1, 2017, pending issuance of the MMPA letters of authorization. This approach has been discussed with environmental staff representatives of the Air Force.

We may request additional data or information as the consultation progresses. If the Air Force makes any substantial changes to the proposed action that alters our effects analysis, or if new data or information needs are identified, NMFS will request an extension of formal consultation in order to complete our effects analysis for this project. Examples of such changes in our effects analysis could be the identification of an increase or decrease in potential adverse effects to ESA-listed species or designated critical habitat, or the addition or omission of any activity to be permitted by the proposed action other

Printed on Recycled Paper

than those described in the initiation package and subsequent communications before formal consultation was initiated.

The ESA requires that after initiation of formal consultation, the Action Agency may not make any irreversible or irretrievable commitment of resources that would preclude the formulation or implementation of any reasonable and prudent alternatives that would avoid violating section 7(a)(2) (50 CFR 402.09). This prohibition is in force during the consultation process and continues until the requirements of section 7(a)(2) are satisfied.

If you have questions regarding the consultation, please contact Mr. Eric MacMillan, ESA Interagency Cooperation Division at (301) 427-8428 or Eric.MacMillan@noaa.gov.

Sincerely,

Cathryn E. Tortorici
Chief, ESA Interagency Cooperation Division
Office of Protected Resources

Amendment to LRS WSEP Programmatic BA (August 30, 2016)

DEPARTMENT OF THE AIR FORCE
AIR FORCE CIVIL ENGINEER CENTER
JOINT BASE SAN ANTONIO LACKLAND TEXAS

AFCEC/CZN
2261 Hughes Ave., Ste. 155
JBSA Lackland, TX 78236-9853

30 August, 2016

Ms. Cathryn E. Tortorici
Chief, ESA Interagency Cooperation Division
Office of Protected Resources
National Marine Fisheries Service
1315 East-West Highway
Silver Spring, MD 20910

SUBJECT: Amendment to the Programmatic Biological Assessment for Long Range Strike Weapon Systems Evaluation Program including a Conference Assessment on the proposed de-listing of the Central North Pacific (Hawaii) Distinct Population Segment of humpback whales

Dear Ms. Tortorici,

On June 15, 2016 the Air Force Civil Engineering Center (AFCEC) submitted a Programmatic Biological Assessment (BA) to initiate consultation under Section 7 of the Endangered Species Act (ESA) for activities described under the Preferred Alternative in the Long Range Strike Weapon Systems Evaluation Program (WSEP) Environmental Assessment/Overseas Environmental Assessment (EA/OEA). The Programmatic BA analyzed potential impacts to the following ESA-listed species: humpback whale, blue whale, fin whale, sei whale, sperm whale, Hawaiian monk seal, green sea turtle, hawksbill sea turtle, loggerhead sea turtle, olive ridley sea turtle, and leatherback sea turtle. As stated in Section 2.0 of the Programmatic BA, Long Range Strike WSEP missions for 2016 were originally proposed to occur on September 1, 2016. However, due to scheduling issues, the mission date has been delayed and is now planned to occur on October 20, 2016, with a back-up date of October 21, 2016. This letter is being submitted to amend the Programmatic BA based on the changes to the mission date and to analyze impacts to additional species that are known to occur in the Study Area (see Figure 1-1 in the Programmatic BA) during the fall.

There are no changes to Long Range Strike WSEP missions proposed for 2017-2021, therefore the impact analysis for this component of the Proposed Action are the same. However, since Long Range Strike WSEP missions proposed for 2016 have been delayed to the fall, additional impacts to baleen whale species that occur in the BSURE area during this time frame will be assessed. Since impacts to species that occur year round would not change from the mission delay, the analyses and determinations for the following species would be the same as indicated in the Programmatic BA: sperm whale, false killer whale, Hawaiian monk seals, green sea turtle, hawksbill sea turtle, loggerhead sea turtle, olive ridley sea turtle, and leatherback sea turtle. This amendment will only focus on humpback whale, blue whale, fin whale, and sei whale. Descriptions of each of these species are included in Sections 3.1.1 through 3.1.4 of the Programmatic BA.

Physical Strike and Ingestion Stressors

Sections 4.1.1 and 4.1.2 of the Programmatic BA discuss the potential impacts to ESA-listed marine mammals from physical strike and ingestion stressors associated with the proposed action. The Air Force does not anticipate that the presence of baleen whale species in the fall would substantially increase the potential for impacts of physical strike from or ingestion of military expended materials. The analysis presented in these sections of the Programmatic BA would still be applicable to baleen whales. Therefore the Air Force feels that the potential for direct strike and ingestion of military expended materials from Long Range Strike WSEP missions **may affect, but is not likely to adversely affect** humpback whales, blue whales, fin whales, and sei whales.

Detonation Effects

Refer to Section 4.1.3 of the Programmatic BA for a discussion on the methodology used to assess impacts to marine mammals from detonation effects associated with Long Range Strike WSEP mission activities. Section 4.1.4 provides a discussion of how marine mammal densities were derived to be included in the analysis. Table 4-2 shows density estimates for all ESA-listed marine mammals that may occur in the Study Area by season and is also included below.

Table 4-2 Marine Mammal Density Estimates (from the Programmatic BA)

Species	Density Estimate (animals per square kilometer)			
	Fall	Spring	Summer	Winter
Humpback whale	0.02110	0.02110	0	0.02110
Blue whale	0.00005	0.00005	0	0.00005
Fin whale	0.00006	0.00006	0	0.00006
Sei whale	0.00016	0.00016	0	0.00016
Sperm whale	0.00156	0.00156	0.00156	0.00156
False killer whale (MHI)	0.00080	0.00080	0.00080	0.00080
Hawaiian monk seal	0.00003	0.00003	0.00003	0.00003

MHI = Main Hawaiian Islands Insular Stock

Previously, impact assessments from detonation effects incorporated summer density estimates from the table above to estimate the number of marine mammals potentially exposed to the criteria and thresholds associated with mortality, Level A Harassment, and Level B Harassment, as discussed in Section 4.1.3 of the Programmatic BA. Updated take estimates of baleen whales incorporating fall densities have been calculated and are included in the table below.

Number of Baleen Whales Potentially Affected by Long Range Strike WSEP Missions (2016)

Species	Mortality (Criterion)	Level A Harassment (PTS)	Level B Harassment (TTS)	Level B Harassment (Behavioral)
Humpback whale	0	0	3	9
Blue whale	0	0	0	0
Fin whale	0	0	0	0
Sei whale	0	0	0	0

MHI = Main Hawaiian Islands Insular Stock; PTS = permanent threshold shift; TTS = temporary threshold shift

The results indicate that there would be no exposures to blue whale, fin whale and sei whale to sound or pressure levels corresponding to mortality, Level A, and Level B harassment. Therefore, the Air Force concluded that detonation effects from Long Range Strike WSEP 2016 missions **may affect, but are not likely to adversely affect** blue whales, fin whales and sei whales.

A total of three humpback whales may be exposed to non-injurious temporary threshold shift (TTS) Level B harassment and nine humpback whales may be exposed to sound levels corresponding to the Level B Behavioral threshold. Humpback whales potentially impacted by Long Range Strike WSEP missions proposed for 2016 belong to the Central North Pacific stock, which primarily consists of winter and spring populations of the Hawaiian Islands that migrate to the northern British Columbia and Alaska, the Gulf of Alaska, the Bering Sea, and Aleutian Islands. The Western North Pacific stock and the California/Oregon/Washington stock do not occur in the Study Area. As stated in Section 4.1.3 of the Programmatic BA, while TTS is a physiological impact, it is not considered injury because auditory structures are temporarily fatigued instead of being permanently damaged. Auditory fatigue is essentially a reduction in hearing ability resulting from overstimulation to sounds that may result from damage or distortion of the tympanic membrane and hair cells, hair cell death, changes in cochlear blood flow, and cochlear nerve swelling. It is assumed that hearing ability of impacted animals would eventually return to pre-exposure levels and would therefore not suffer from reductions in health or reproductive success. Similarly, there would be no changes in their habitat utilization. Level B Behavioral harassment would occur at distances beyond the range of a hearing threshold shift and could result in either an alteration in natural behaviors or avoidance of an area. Example behavioral responses to a detonation could include panic, startle, departure from an area, and disruption of activities such as feeding or breeding. Given that 2016 missions are only planned to occur on one day for up to four hours, any behavioral impacts are anticipated to be temporary and would not result in long-term population level impacts. The Air Force therefore concludes that detonation effects from Long Range Strike WSEP 2016 missions **may affect and are likely to adversely affect** individual humpback whales. Adherence to the mitigation measures described in Section 5.0 of the Programmatic BA are expected to reduce the potential for impacts and population level effects to humpback whales are not anticipated.

Conference Assessment on the Proposed De-Listing of the Hawaii DPS of Humpback Whales

On April 31, 2015, NMFS announced a proposal to divide humpback whales into 14 DPSs, including a Hawaii DPS, and to revise the listing status for the various segments (50 Code of Federal Regulations (CFR) Parts 223 and 224, 21 April 2015). Under the proposal, the current Central North Pacific stock is identified as the Hawaii DPS and would be delisted based on a positive 12-month finding on a petition to remove the DPS from the List of Endangered and Threatened Species under the ESA. The proposed rule concluded that the Hawaii DPS, among others, is not in danger of extinction throughout all or a significant portion of its range and is not likely to become so in the foreseeable future. If the delisting of the Hawaii DPS becomes finalized, the provisions of the ESA, including the requirement for federal agencies to consult with NMFS under Section 7 of the ESA, would no longer apply. If the Final Rule to identify the 14 DPSs of humpback whales and revisions of species-wide listing is issued as it was proposed in 50 CFR Parts 223 and 224 before Long Range Strike WSEP consultations are completed, then the Air Force requests that NMFS remove humpback whales from consideration in the biological opinion. In either case, the Hawaii DPS of humpback whales would still be subject to the provisions of the Marine Mammal Protection Act (MMPA). Pursuant to the MMPA, the Air Force is requesting small numbers of takes of marine mammals under an Incidental Harassment Authorization for Long Range Strike WSEP 2016 missions and a Letter of Authorization for Long Range Strike WSEP 2017-2021 missions.

Conclusion

Based on the analysis in this amendment, AFCEC has made the following updated determinations:

- Long Range Strike WSEP 2016 missions **may affect, but are not likely to adversely affect** blue whales, fin whales, sei whales, sperm whale, false killer whale, and Hawaiian monk seals.
- Long Range Strike WSEP 2016 missions **may affect, and are likely to adversely affect** humpback whales.
- If the Central North Pacific stock (Hawaii DPS) of humpback whales are effectively de-listed prior to completing the biological opinion and issuing the incidental take statement, AFCEC requests that NMFS remove this species from the consultation.

If you have any questions regarding this amendment, please do not hesitate to contact either Ms. Amanda Robydek at (850) 882-8395; amanda.robydek.ctr@us.af.mil or myself at (210) 925-2741; michael.ackerman.2@us.af.mil

Sincerely,

Michael Ackerman
Program Manager
NEPA Division (AFCEC/CZN)

CC: Lt. Col. Sean B. Neitzke, Commander, 86 Fighter Weapon Squadron

Long Range WSEP 2016 Mission Biological Opinion (September 28, 2016) with Cover Letter

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Silver Spring, MD 20910

SEP 28 2016

Mr. Michael Ackerman
Program Manager, NEPA Division (AFCEC/CZN)
Department of the Air Force
Air Force Civil Engineer Center
2261 Hughes Ave, Ste. 155
JBSA Lackland, TX 78236-9853

RE: Endangered Species Act section 7 consultation biological opinion on the United States Air Force's 2016 Long Range Strike Weapons Systems Evaluation Mission off Hawaii [FPR-2016-9160]

Dear Mr. Ackerman:

Enclosed is the National Marine Fisheries Service's (NMFS) biological opinion on the effects of the Air Force's 2016 Long Range Strike Weapons System Evaluation mission off Hawaii on endangered and threatened species under NMFS's jurisdiction and critical habitat that has been designated for those species. We have prepared the biological opinion pursuant to section 7(a)(2) of the Endangered Species Act, as amended (ESA; 16 U.S.C. 1536(a)(2)).

Based on our assessment, we concluded that the proposed action is likely to adversely affect, but not likely to jeopardize the continued existence of, threatened and endangered species under NMFS's jurisdiction and will not destroy or adversely modify designated critical habitat.

This biological opinion concludes section 7 consultation on the Air Force's 2016 Long Range Strike Weapons Systems Evaluation mission. The Air Force is required to reinitiate formal consultation on the proposed action, where it retains discretionary involvement or control over the action and if: (1) the amount of extent of incidental take is exceeded; (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion; (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this opinion; or (4) a new species is listed or critical habitat designated that may be affected by the action.

If you have any questions regarding this biological opinion, please contact Cathy Tortorici at (301) 427-8495 or cathy.tortorici@noaa.gov.

Sincerely,

Donna S. Wieting

Donna S. Wieting
Director, Office of Protected Resources

Printed on Recycled Paper

NATIONAL MARINE FISHERIES SERVICE
ENDANGERED SPECIES ACT SECTION 7 BIOLOGICAL OPINION

Action Agencies: United States Air Force

Activity Considered: Operational evaluations of live long range strike weapons and other munitions conducted by the United States Air Force in the Barking Sands Underwater Range Expansion area of the Pacific Missile Range Facility off of the western shores of the island of Kauai in October 2016

Consultation Conducted By: Endangered Species Act Interagency Cooperation Division, Office of Protected Resources, National Marine Fisheries Service

Approved:

Donna S Wieting

Donna S. Wieting
Director, Office of Protected Resources

Date: SEP 28 2016

Public Consultation Tracking System number: FPR-2016-9160

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1 Introduction

The Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 et seq.) establishes a national program for conserving threatened and endangered species of fish, wildlife, plants, and the habitat they depend on. Section 7(a)(2) of the ESA requires Federal agencies to insure that their actions are not likely to jeopardize the continued existence of endangered or threatened species or adversely modify or destroy their designated critical habitat. Federal agencies must do so in consultation with National Marine Fisheries Service (NMFS) the United States Fish and Wildlife Service (USFWS) or both (the Services), depending upon the endangered species, threatened species, or designated critical habitat that may be affected by the action. If a Federal agency's action may affect a listed species or designated critical habitat, the agency must consult with NMFS, USFWS, or both (50 CFR §402.14(a)). If a Federal action agency determines that an action "may affect, but is not likely to adversely affect" endangered species, threatened species, or designated critical habitat and NMFS, the USFWS, or both concur with that determination, consultation concludes informally (50 CFR §402.14(b)).

Section 7 (b)(3) of the ESA requires that at the conclusion of consultation, NMFS and/or USFWS provide an opinion stating how the Federal agencies' actions will affect ESA-listed species and their critical habitat under their jurisdiction. If an incidental take is expected, section 7 (b)(4) requires the consulting agency to provide an incidental take statement that specifies the impact of any incidental taking and includes reasonable and prudent measures to minimize such impacts.

For the actions described in this document, the action agency is the United States Air Force (Air Force), which proposes to conduct operational evaluations of live ordnance deployment (long-range strike weapons and other munitions) off of the island of Kauai, Hawaii. The consulting agency for this proposal is NMFS Office of Protected Resources, ESA Interagency Cooperation Division.

The biological opinion (opinion) and incidental take statement were prepared by NMFS ESA Interagency Cooperation Division in accordance with section 7(b) of the ESA and implementing regulations at 50 CFR §402. This document represents NMFS's opinion on the effects of these actions on endangered and threatened species and critical habitat that has been designated for those species. A complete record of this consultation is on file at NMFS Office of Protected Resources in Silver Spring, Maryland.

1.1 Background

This opinion is based on information provided by the Air Force during pre-consultation and in the June 16, 2016, request for ESA formal consultation, which included a biological assessment and two appendices, one containing acoustic modelling methodology and the other containing marine species depth distribution data. The Air Force proposes to conduct operational evaluations of live long-range strike weapons and other munitions in the Barking Sands

Underwater Range Expansion (BSURE) area of the Pacific Missile Range Facility (PMRF) in Hawaii off of the western shores of the island of Kauai. Munitions will be deployed from aircraft. Activities are expected to occur in October 2016. The Air Force has not previously conducted these activities in the PMRF, but similar activities (i.e., use of explosive ordnance) are conducted on a regular basis in the PMRF by the United States Navy.

1.2 Consultation History

On February 29, 2016, NMFS Office of Protected Resources ESA Interagency Cooperation Division received a preliminary draft Environmental Assessment (EA) from the Air Force on their proposed operational evaluations of live long-range strike weapons and other munitions in the BSURE area of the PMRF.

On April 11, 2016, NMFS received updated preliminary documents including marine mammal density estimates, an acoustic modeling appendix, and a marine mammal take summary table.

On April 14, 2016, NMFS provided a recommendation to the Air Force for the appropriate threshold to use for behavioral harassment of sea turtles.

On June 16, 2016, NMFS received a request for formal consultation pursuant to section 7 of the ESA on proposed long-range strike Weapons Systems Evaluation Program operational evaluations to be conducted in the BSURE area on the west coast of the island of Kauai, Hawaii from 2016 through 2021. The request for formal consultation included a Biological Assessment of the proposed action.

On July 1, 2016, following initial review of the Air Force's request for formal consultation, NMFS determined there was sufficient information to initiate formal consultation. However, we indicated that we would not be able to complete a formal programmatic consultation on all of the Long Range Strike Weapon Systems Evaluation Program mission activities proposed by the Air Force (i.e., activities from 2016 through 2021) before September 1, 2016, (i.e., the date 2016 activities were scheduled to commence). Through discussions with the Air Force, agreement was reached to conduct a consultation on activities proposed in 2016, which are smaller in scope than the activities that will start in 2017. This consultation was to be completed on or before August 29, 2016. For activities proposed from 2017 through 2021, we indicated that we would conclude consultation on or before July 1, 2017, pending issuance of the Marine Mammal Protection Act (MMPA) letters of authorization.

On August 24, 2016, the Air Force informed NMFS that the proposed mission for 2016 would not occur in September as originally planned but would be postponed until October 20, 2016, with October 21, 2016 as a back-up date. Due to this change in the proposed action, NMFS informed the Air Force that we would not complete our biological opinion until the end of September 2016.

On August 30, 2016, the Air Force submitted an amendment to the Long Range Strike Weapon Systems Evaluation Program mission Biological Assessment (originally submitted June 16,

2016) requesting that if the rule to revise the listing status of humpback whales was finalized as proposed (80 FR 22304), that NMFS remove humpback whales from consideration in both of the consultations.

On September 8, 2016 NMFS published a final rule to revise the listing status of the humpback whale under the ESA (81 FR 62259). Consistent with the proposed rule (80 FR 22304), humpback whales from the Hawaii Distinct Population Segment (DPS) are no longer listed under the ESA and will not be considered in this consultation or the future consultation on the Long Range Strike Weapon Systems Evaluation Program mission.

2 Description of the Proposed Action

"Action" means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by federal agencies.

The Air Force proposes to conduct air-to-surface operational evaluations of live, long-range strike weapons off of the western coast of Kauai, Hawaii in October 2016. This operational program uses long-range strike weapons systems, along with other munitions (bombs and missiles) and would be carried out by the 86th Fighter Weapons Squadron (86 FWS). The Air Force will conduct the mission in the BSURE area of the PMRF. The PMRF is part of the Navy's Hawaii Range Complex (HRC) and was chosen because it supports the full range of tasks for the proposed action. The impact area will be approximately 44 nm (81 km) offshore of Kauai, Hawaii in a water depth of approximately 4,645 m (15,240 ft). There will not be any ground-based or nearshore activities requiring the use of any shoreline in Kauai. The purpose of the activities performed by the Air Force in the BSURE area is to conduct daytime operational evaluations of long-range strike weapons and other munitions in order to properly train and score units of the Air Force in their ability to effectively execute scenarios that resemble realistic operations in a time of war. The ordnance may be delivered by bombers and fighter aircraft and will detonate and be scored at the surface of the water in the BSURE area.

2.1 Aircraft Operations

The aircraft used may include bombers and fighter aircraft for the purpose of releasing weapons and range clearance, and the P-3 Orion or the P-8 Poseidon to relay telemetry and flight termination system streams between weapon and ground stations. There will also be support aircraft available for range clearance activities and air-to-air refueling before and during the mission. All aircrafts associated with releasing weapons would originate from an out base (i.e., Ellsworth Air Force Base [AFB], Dyess AFB, Barksdale AFB, Whiteman AFB, Minot AFB, Mountain Home AFB, Nellis AFB, Hill AFB, JB Hickam-Pearl Harbor, JB Elmendorf-Richardson, or JB Langley-Eustis) and fly into military controlled airspace prior to the mission. Due to the long transit times between the out bases and the action area, air-to-air refueling of weapon delivery aircraft may be conducted. An operational flight for each aircraft deploying a munition would consist of delivering the weapons, conducting air-to-air refueling, and returning to their base of origin. Multiple weapon-release aircraft would be used during the mission. All aircraft flight maneuver operations and weapon releases would occur within Warning Area 188A (W-188A), located offshore of Kauai. The aircraft supporting the mission within the warning area would generally fly below 3,000 feet for enough time to escort non-military vessels outside of the action area or to monitor the action area for marine protected species (see Section 2.4 for range clearance procedures).

2.2 Long-Range Strike Munitions

The proposed operational evaluations of live long-range strike weapons and other munitions mission would release eight live (explosive) Small Diameter Bomb-Is (SDB-I) and one Joint Air-to-Surface Stand-off Missile/Joint Air-to-Surface Stand-off Missile-Extended Range (JASSM/ER). All releases will occur in one day within the PMRF. A description of the two munitions used in the 2016 Long Range Strike Weapon Systems Evaluation Program mission is including in the following subsections.

2.2.1 Small Diameter Bomb-I

The Small Diameter Bomb-I is a 250-pound air-launched guided weapon with Global Positioning System (GPS) technology and an Internal Navigation System (INS). The weapon has a range of up to 60 nm (111 km), and they each contain 37 pounds of 2,4,6-trinitrotoluene (TNT) equivalent net explosive weight, using AFX-757, a type of plastic-bonded explosive, as the specific type of explosive.

2.2.2 Joint Air-to-Surface Stand-off Missile/Joint Air-to-Surface Stand-Off Missile-Extended Range (JASSM/JASSM-ER)

The Joint Air-to-Surface Stand-off Missile is a precision cruise missile with a range of more than 200 nm (370 km) and the capability to fly a preprogrammed route from launch to a target. It carries a 1,000-pound warhead with approximately 300 pounds of TNT-equivalent net explosive weight. Like the SMD-I, the type of explosive used for the JASSM is AFX-757. The JASSM-ER has additional fuel and a different engine for a greater range than the JASSM (500 nm [926 km]), but it functions the same way as the JASSM.

2.3 Schedule and Mission Procedures

The evaluation of live long-range strike weapons and other munitions is scheduled for October 20, 2016, with a back-up day scheduled for October 21, 2016. This mission will consist of releasing one live JASSM/JASSM-ER and eight SDB-I, and every release is expected to result in a surface detonation.

The mission day would involve pre-mission checks, safety review, crew briefing, weather checks, clearing airspace, range clearance, minimization/monitoring efforts, and other military protocols prior to the launch of weapons. These standard operating procedures usually occur in the morning and live range time may begin in the late morning once all checks are complete and approval is granted from range control. On the day of the mission, the range would be closed to the public for a maximum of four hours. There are several possible factors that could cause a mission delay including, but not limited to, adverse weather conditions leading to unsafe take-off, landing, and aircraft operations; inability to clear the range of non-mission vessels or aircraft; mechanical issues with mission aircraft or munitions; or presence of marine protected species in the impact area.

Long range strike weapons would complete their maximum flight range at an altitude of approximately 18,000 ft (5,486 m) above mean sea level (MSL) and terminate at a specified location. The cruise time for a SDB-I is approximately 10 minutes whereas the JASSM/JASSM-ER takes about 45 minutes. Although the time between successive munitions deployment may vary slightly, they could be spaced by approximately one hour to account for the JASSM cruise time. Weapon release parameters for the mission would involve a B-1 bomber releasing one live JASSM and fighter aircraft, such as F-15, F-16, or F-22, releasing eight live SDB-I. Up to four SDB-I munitions would be released simultaneously, similar to a ripple effect, each hitting the water surface within a few seconds of each other. The release of the eight SDB-I munitions would occur separately from the JASSM release, but all releases would occur on the same mission day. The final impact point on the water surface would be programmed into the munitions for weapons scoring and evaluations.

All aspects of the mission would follow applicable flight safety, hazard, and launch parameter requirements established for PMRF. A weapon hazard area would be established, with the size and shape of the area determined by the maximum distance a weapon could travel in any direction during its descent. This hazard area is usually adjusted for potential wind speed and direction, which allows for the maximum composite safety area for the mission (each safety area boundary is at least 12 nm from the Kauai coastline). This information is used to establish a Launch Exclusion Area and Aircraft Hazard Area. These exclusion areas must be verified to be clear of all non-mission and non-essential vessels and aircraft before live weapons are released. Prior to the release of a weapon, a range sweep of the hazard area would be conducted by other aircraft involved in the mission, potentially including S-61N helicopter, C-26 aircraft, fighter aircraft (F-15E, F-16, F-22), or the Coast Guard’s C-130 aircraft. Due to the presumably large safety area associated with the mission, it is unlikely that smaller vessels would be able to clear the necessary areas; thus, range clearing activities would be conducted solely by aircraft.

2.4 Mitigation Measures, Monitoring, and Reporting

In order to minimize the risk to protected marine species associated with explosive ordnance detonation, pre-mission aerial surveys will be conducted of the impact area for the presence of marine mammals and sea turtles. To complete the aerial survey for this mission, Navy test range personnel will inspect the area from mission aircraft (typically jet aircraft such as F-15E, F-16, or F-22) or a U.S. Coast Guard C-130 aircraft. The aircrew tasked with observing protected species will be trained and will have experience conducting aerial marine mammal surveys. The aircrew will have provided similar support for other missions at PMRF.

Protected species surveys will begin as close to the impact time as feasible (usually within one hour of weapon release), taking into account human safety requirements. Personnel will conduct aerial surveys within an area defined by an approximately 2 nm (3,704 m) radius around the impact point, with aerial surveys typically following a star pattern. This survey distance encompasses all mortality, physical injury (e.g., slight lung injury), and permanent threshold shift (PTS) impact areas for ESA-listed marine mammals and sea turtles. All temporary threshold shift (TTS) impact areas for ESA-listed marine mammals are covered in this area, but the survey distance only covers approximately 50 percent of the TTS impact area for sea turtles. Given operational constraints, surveying larger areas would not be feasible (Department of the Air Force 2016). If daytime weather and/or sea conditions preclude adequate monitoring for detecting marine mammals and sea turtles, operations will be delayed until adequate sea conditions exist for monitoring to be undertaken. Aerial surveys are typically conducted at an altitude of approximately 200 feet but may vary depending on sea state and atmospheric conditions. Pre-mission surveys usually last approximately 30 minutes once the aircraft reaches the impact area, though the time may vary slightly based on the survey pattern. If adverse weather conditions prevent the aircraft from operating safely, the mission would either be delayed until the weather clears or the mission would be cancelled for the day and the mission would occur on the back-up weather day (October 21, 2016). If a protected species is observed in the impact area, weapon release would be delayed until one of the following conditions is met: (1) the animal is observed exiting the impact area, (2) the animal is thought to have exited the impact area based on its course and speed, or (3) the impact area has been clear of any additional sightings for 30 minutes.

Post-mission surveys would begin immediately after the mission is complete and the Range Safety Officer declares the human safety area is reopened. The same aircraft and aircrew that conducted the pre-mission surveys would conduct the post-mission surveys and would follow the same patterns as pre-mission surveys, focusing instead on the area down current of the weapon area impact (as opposed to within the impact area) to determine if protected species were affected by the mission (i.e., observation of dead or injured animals). NMFS would be notified if post-mission surveys reveal any injured or otherwise adversely affected ESA-listed animals, and all records would be sealed and held for investigation should injury or mortality occur to a protected species.

In the event that activities clearly cause the take of an ESA-listed marine mammal or sea turtle in a manner not authorized by NMFS, the Air Force will immediately cease activities and report the incident to the NMFS Office of Protected Resources and the Regional Stranding Coordinator. Activities will not resume until NMFS reviews the circumstances of the take and determines what further measures are necessary to minimize the likelihood of further prohibited take. Additionally, if an injured or dead marine mammal or sea turtle is discovered and the cause of injury or death is unknown and occurred relatively recently (i.e., with respect to the proposed action), the Air Force will immediately report the incident to the NMFS Office of Protected Resources and the Regional Stranding Coordinator. Lastly, if an injured or dead marine mammal or sea turtle is discovered, and the observer determines that the injury or death is not related to operational evaluations of live long-range strike weapons and other munitions activities, the Air Force will report the incident to NMFS Office of Protected Resources and the Regional Stranding Coordinator within 24 hours, and may provide photographs, video footage, or other documentation of the affected animal.

2.5 Action Area

Action area means all areas affected directly, or indirectly, by the Federal action and not just the immediate area involved in the action (50 CFR 402.02).

The action area for this opinion is the PMRF, which is part of the HRC, and is located off the western shores of the island of Kauai, Hawaii in the Pacific Ocean and includes marine areas to the north, south, and west (Figure 1). The HRC is a major range and test facility base that supports the full spectrum of the Department of Defense test and evaluation requirements. The HRC consists of ocean areas located around the major islands of the Hawaiian Island chain and consists of surface and subsurface ocean areas and special use airspace. The PMRF is the world's largest instrumented, multi-environment military training and testing range capable of supporting subsurface, surface, air, and space operations. The PMRF includes 1,020 nm^2 of instrumented ocean areas at depths between 549 m (1,800 ft) and 4,572 m (15,000 ft), 42,000 nm^2 of controlled airspace, and a temporary operating area covering 2.1 million nm^2 of ocean area.

Within the PMRF, activities will occur in the BSURE area, which lies within W-188A (Figure 2). The BSURE area is comprised of approximately 900 nm^2 of instrumented underwater ranges, encompassing the deep water portion of the PMRF and providing over 80 percent of PMRF's underwater scoring capability (with regards to scoring missions). The impact area is approximately 44 nm (81 km) offshore of Kauai, Hawaii, in a water depth of about 4,645 m (15,240 ft). All aspects of the operational evaluations of live long-range strike weapons and other munitions mission will take place over open ocean areas. There will be no ground or nearshore activities requiring the use of any shoreline areas of Kauai.

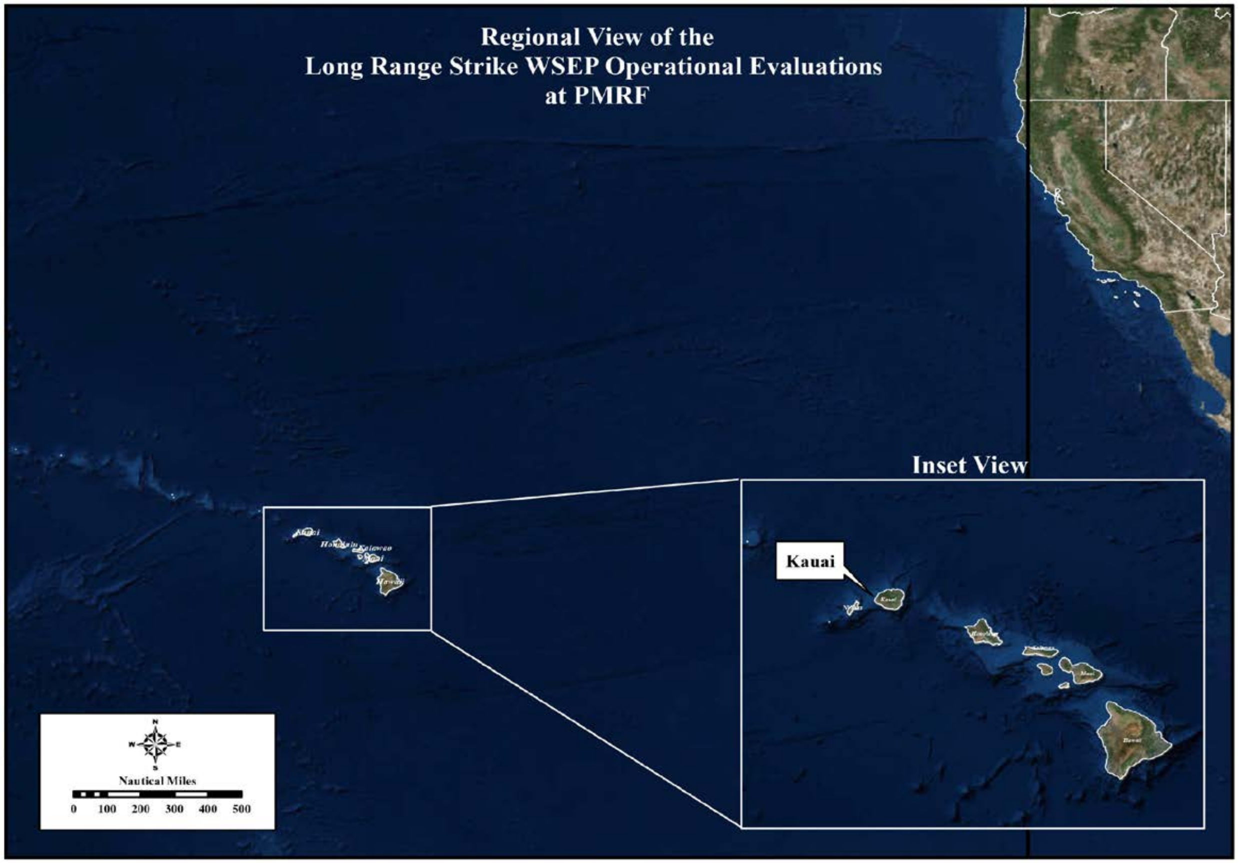


Figure 1. A regional view of the Hawaiian Islands with a close up of the location of the island of Kauai. All Long Range Strike Long Range Strike Weapon Systems Evaluation Program mission operations in 2016 will take place off of the west coast of Kauai (Department of the Air Force 2016).

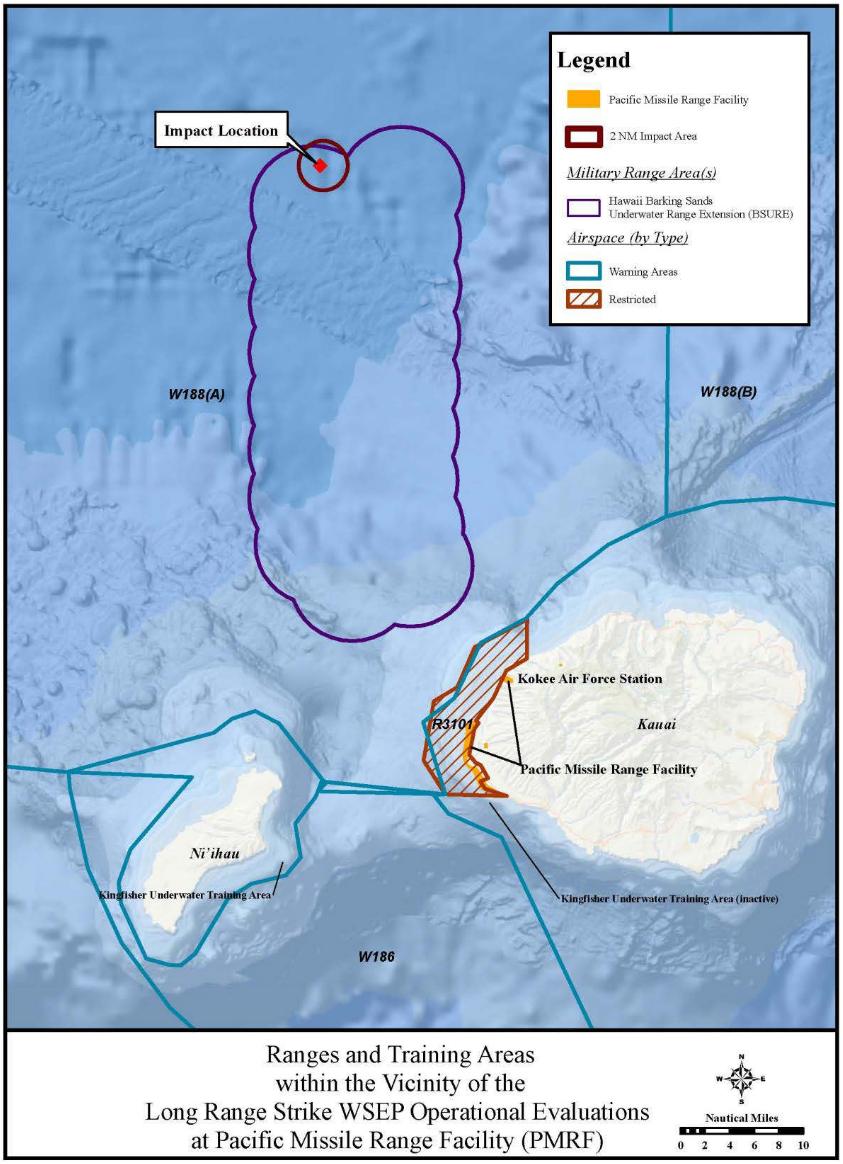


Figure 2. Map of the Pacific Missile Range Facility off of the coast of Kauai, including the Hawaii Barking Sounds Underwater Range Expansion area, the 2 nm (3.7 km) area of impact, and the impact location (Department of the Air Force 2016).

3 Overview of Assessment Framework

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

"To jeopardize the continued existence of an ESA-listed species" means to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of an ESA-listed species in the wild by reducing the reproduction, numbers, or distribution of that species (50 CFR §402.02). The jeopardy analysis considers both survival and recovery of the species.

Section 7 assessment involves the following steps:

1) We identify the proposed action and those aspects (or stressors) of the proposed action that are likely to have direct or indirect effects on the physical, chemical, and biotic environment within the action area, including the spatial and temporal extent of those stressors.

2) We identify the ESA-listed species and designated critical habitat that are likely to co-occur with those stressors in space and time.

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

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

5) We evaluate the available evidence to determine how those ESA-listed species are likely to respond given their probable exposure. This is our response analyses.

6) We assess the consequences of these responses to the individuals that have been exposed, the populations those individuals represent, and the species those populations comprise. This is our risk analysis.

7) The adverse modification analysis considers the impacts of the proposed action on the critical habitat features and conservation value of designated critical habitat.

8) We describe any cumulative effects of the proposed action in the action area.

Cumulative effects, as defined in our implementing regulations (50 CFR §402.02), are the effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area. Future Federal actions that are unrelated to the proposed action are not considered because they require separate section 7 consultation.

9) We integrate and synthesize the above factors by considering the effects of the action to the environmental baseline and the cumulative effects to determine whether the action could reasonably be expected to:

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

    b) Reduce the conservation value of designated or proposed critical habitat. These assessments are made in full consideration of the status of the species and critical habitat.

10) We state our conclusions regarding jeopardy and the destruction or adverse modification of critical habitat.

If, in completing the last step in the analysis, we determine that the action under consultation is likely to jeopardize the continued existence of ESA-listed species or destroy or adversely modify designated critical habitat, we must identify a reasonable and prudent alternative (RPA) to the action. The RPA must not be likely to jeopardize the continued existence of ESA-listed species nor destroy or adversely modify their designated critical habitat, and it must meet other regulatory requirements.

Evidence Available for the Consultation

To conduct these analyses, we considered all lines of evidence available through published and unpublished sources that represent evidence of adverse consequences or the absence of such consequences. A considerable body of scientific information on anthropogenic sounds and their effects on marine mammals, sea turtles, fishes, and other aquatic organisms is available. NMFS's status reviews for listed species also provide information on the status of the species including, but not limited to, their resiliency, population trends, and specific threats to recovery that contributes to our *Status of Listed Resources*, *Environmental Baseline*, and *Risk Analyses* sections.

To comply with our obligation to use the best scientific and commercial data available, we conducted electronic literature searches throughout the consultation, including within NMFS Office of Protected Resource's electronic library. We examined the literature that was cited in the submittal documents and any articles we collected through our electronic searches. We also considered the documents provided to NMFS by the Air Force, including the Biological Assessment and acoustic modelling methodology and marine species depth distribution appendices.

Considering the information that was available, this consultation and our opinion include uncertainty about the basic hearing capabilities of some ESA-listed species, how these taxa use sounds as environmental cues, how they perceive acoustic features of their environment, the importance of sound to the normal behavioral and social ecology of species, the mechanisms by which human-generated sounds affect the behavior and physiology (including the non-auditory physiology) of exposed individuals, and the circumstances that are likely to produce outcomes that have adverse consequences for individuals and populations of exposed species.

3.1 The Air Force's Exposure Analysis

To estimate potential exposure of marine mammals and sea turtles to sounds from detonations, the Air Force used acoustic modeling and marine mammal and sea turtle density information. We summarize the Air Force's exposure analysis below. A comprehensive description of this analysis is included in the Air Force's Long Range Strike Weapons System Evaluation Program Biological Assessment and appendices (Department of the Air Force 2016). We verified the methodology and data used by the Air Force for their exposure analysis and accept the modeling conclusions on exposure of marine mammals and sea turtles.

Three sources of information were used to estimate potential detonation effects on marine mammals and sea turtles: (1) the zone of influence; (2) the density of animals within the zone of influence (see below for species density estimates); and (3) the number of detonations (events). The zone of influence is the area or volume of ocean in which marine mammals or sea turtles could be exposed to various pressure or acoustic energy levels caused by exploding ordnance. To determine the zone of influence, the Air Force used acoustic modeling (thoroughly described in Appendix A of (Department of the Air Force 2016), which incorporated the criteria and thresholds presented in Finneran and Jenkins (2012). Criteria are the types of possible effects and include mortality, injury (e.g., PTS, slight lung injury), and harassment (i.e., TTS, behavioral harassment). Threshold is the level of pressure or noise above which impact criteria are reached.

The acoustic modeling calculated the maximum estimated range, or radius, from the detonation point to which the various thresholds extend for all munitions proposed to be released during the 2016 mission. Table 1 lists the estimated ranges for the 2016 mission. The ranges were used to calculate the total area (circle) of the zones of influence for each criterion/threshold. To eliminate "double counting" of animals, impact areas from higher impact categories (e.g., mortality) were subtracted from areas associated with lower impact categories (e.g., PTS). The estimated number of marine mammals and sea turtles potentially exposed to the various impact thresholds was then calculated as the product of the adjusted impact area (i.e., zone of influence), animal density, and the number of events per year (i.e., only one for 2016). Since the acoustic model accumulates energy from all detonations within a 24-hour timeframe, it is assumed the same population of animals is being impacted within that time period. For metrics with multiple criteria (e.g., PTS), the criterion and/or threshold that results in the higher exposure estimate was used.

Table 1. Threshold radii (in meters) for Long Range Strike Weapon Systems Evaluation Program mission.

Species	Mortality	Slight Lung Injury	GI Tract Injury	PTS (SEL[1])	PTS (SPL[2])	TTS (SEL)	TTS (SPL)	Behavioral (SEL)
Blue whale	28	59	165	2,161	330	6,565	597	13,163
Fin whale	28	62	165	2,161	330	6,565	597	13,163
Sei whale	38	83	165	2,161	330	6,565	597	13,163
Sperm whale	33	72	165	753	330	3,198	597	4,206
False Killer Whale (MHI[3] DPS)	72	153	165	753	330	3,198	597	4,206
Hawaiian Monk Seal	135	256	165	1,452	1,107	3,871	1,881	6,565
Pacific sea turtles[4]	153	285	165	2,328	329	6,558	597	6,129

[1]Sound exposure level
[2]Sound pressure level
[3]Main Hawaiian Islands
[4]Pacific sea turtles includes a combined group of green, hawksbill, olive ridley, loggerhead, and leatherback sea turtles.

This exposure analysis is conservative because it does not take into account the mitigation measures employed by the Air Force (described in Section 2.4) to minimize impacts to marine mammals and sea turtles. These measures would be expected to decrease the potential for explosive impacts. In addition, exposure calculations are based on the assumption that all animals would occupy the same depth within the water column and do not take into account diving behavior, which could decrease exposure levels.

Density estimates

The Air Force used density estimates for acoustic analysis from the DRAFT U.S. Navy's Marine Species Density Database (NMSDD) Phase III for the Hawaii-Southern California Training and Testing Study Area (U.S. Department of the Navy 2016). The Navy database includes a compilation of the best available density data from several primary sources and published works, including NMFS survey data within the Hawaiian Islands Exclusive Economic Zone. NMFS publishes annual stock assessment reports for various regions of U.S. waters, which cover all stocks of marine mammals within those waters. Other researchers often publish density data or research covering a particular marine mammal species or geographic area, which is integrated into the stock assessment reports. Density is typically reported for an area (e.g., animals per km^2), and the Air Force assumed that animals are uniformly distributed within the affected area for the purpose of analyzing the proposed action. Based on current regulatory guidance, density is assumed to be two-dimensional, and exposure estimates are calculated as the product of affected area, animal density, and number of events.

Marine mammals

For most marine mammal species, abundance is estimated using line-transect methods that derive densities based on sighting data collected during ship or aerial surveys. Habitat-based models may also be used to model density as a function of environmental variables. Uncertainty in published density estimation is typically large because of the low number of sightings collected during surveys, and some density estimation methods result in greater uncertainty than others. For this analysis, the Navy provided their most recent information on the type of model used to estimate density, along with the sources of uncertainty (expressed as a coefficient of variation), for each marine mammal species in the Hawaii region as part of their latest updates to the NMSDD. For additional information on the data used to estimate marine species densities, see Department of the Air Force (2016).

The NMSDD consists of the most relevant information available for the Hawaii area and has been endorsed by NMFS for use in impacts analyses of previous military actions conducted near the action area. For some species, density estimates are uniform throughout the Hawaii region. For others, densities are provided in multiple, smaller blocks. In these cases, the Air Force used density estimates corresponding to the block containing the impact location. The resulting marine mammal seasonal density estimates used in this document are shown in Table 2. The operational evaluations of live long-range strike weapons and other munitions 2016 mission is scheduled to occur on October 20, 2016, so fall density estimates were used.

Table 2. Marine mammal and sea turtle density estimates in the action area (U.S. Department of the Navy 2016).

Species	Fall Density Estimate (animals per km^2)
Blue whale	0.00005
Fin whale	0.00006
Sei whale	0.00016
Sperm whale	0.00156
False killer whale (MHI insular DPS)	0.00050
Hawaiian monk seal	0.00003
Pacific sea turtles[1]	0.00429

[1]As noted below, the Pacific sea turtle guild includes green, hawksbill, loggerhead, leatherback, and olive ridley sea turtles.

Sea turtles

In-water occurrence data for sea turtles are severely limited (U.S. Department of the Navy 2014). Many studies assess turtle abundance by counting nesting individuals or number of eggs, or by recording bycatch, but in-water densities may not be accurately represented by estimates from such information. Accordingly, density estimates for the HRC are derived entirely from Navy data obtained through dive surveys and projects associated with Integrated Natural Resource Management Plans. Due to the relative scarcity of some species and the lack of density estimates for sea turtles associated with open ocean habitats such as the BSURE area, the Air Force assessed the impacts of the 2016 Long Range Strike Weapon Systems Evaluation Program mission using a single guild (Pacific Sea Turtles), which combines all sea turtle species. This group theoretically encompasses all five species with potential occurrence in the action area, although only green and hawksbill sea turtles are known to have been observed in the HRC by Navy divers and contractors. Loggerhead, leatherback, and olive ridley turtles could pass through the area during migration, but their likelihoods of occurrence are extremely low.

Turtles have primarily been observed by Navy divers and contractors within the 100-m isobath (and usually much shallower than 100-m) around the islands of Kauai, Lanai, Molokai, and Oahu, and density values have been directly calculated only within this depth contour. Densities beyond this depth in the open ocean are expected to be substantially less. For areas of the HRC outside the 100-m isobath, the Navy used the mean density around the islands reduced by two orders of magnitude. The resulting density estimate used for the Air Force impacts analysis is 0.00429 turtles per km^2. This density value corresponds to all life stages of the Pacific sea turtle guild occurring in the open ocean (beyond the 100-m isobath) in all seasons.

Available information suggests that the majority of the sea turtles within the PMRF (and the majority of the sea turtles within the Pacific sea turtle guild) would be green sea turtles from the Central North Pacific DPS. As mentioned above, loggerhead, leatherback, and olive ridley sea turtles were not observed during Navy surveys used to derive sea turtle density data. While these species still could occur in the action area, occurrences would be rare, and these species would only likely be temporarily migrating through the area. Chaloupka et al. (2008c) found that while hawksbills are the second-most abundant species in the offshore waters of the Hawaiian Islands, they are far less abundant than green turtles. This is further supported by stranding data, which indicate that the majority of stranded sea turtles on the Hawaiian Islands are green sea turtles. Ninety-seven percent of sea turtles that strand in the Main Hawaiian Islands are green turtles. Three percent of sea turtles that strand in the Main Hawaiian Islands are hawksbills and olive ridleys, and loggerheads and leatherbacks rarely strand in the Main Hawaiian Islands (Balazs and Chaloupka 2006b).

On April 6, 2016, NMFS published a final rule to list 11 DPSs of green sea turtles as threatened or endangered under the ESA (81 FR 20057). The action area is entirely contained within the DPS delineation of the Central North Pacific DPS. While some green turtles from other DPSs in the Pacific Ocean could occur within the action area during for foraging and migration (i.e., East Indian-West Pacific DPS, Central West Pacific DPS, Southwest Pacific DPS, Central South Pacific DPS, Southwest Pacific DPS, Central South Pacific DPS, and East Pacific DPS), we would expect the vast majority of green turtles within the action area to be from the Central North Pacific DPS.

3.2 Consideration of the National Oceanic and Atmospheric Administration's Marine Mammal Acoustic Technical Guidance

In August 2016, NOAA released its *Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing*, which established new thresholds for predicting auditory injury (i.e., permanent threshold shift). The criteria and thresholds for marine mammals used in the acoustic modeling for this consultation are from Finneran and Jenkins (2012), as opposed to the recently released technical guidance. In the Federal Register Notice of the Technical Guidance, NMFS explained the approach it would take during a transition period, wherein we balance the need to consider this new best available science with the fact that some applicants have already committed time and resources to the development of acoustic analyses based on our previous guidance and have constraints that preclude the recalculation of take estimates, as well where the agency is in the decision-making pipeline. In that Notice, we included a non-exhaustive list of factors that would inform the most appropriate approach for considering the new guidance, including how far in the MMPA authorization process the applicant has progressed, the scope of the effects, when the MMPA authorization is needed, the cost and complexity of the analysis, and the degree to which the guidance is expected to affect our analysis. In this case, the Air Force has requested MMPA authorization (for take of non-ESA listed marine mammal species) and consultation for a one-day activity in October 2016 that would include one explosive release and two explosive bursts of four munitions timed a few seconds apart. The extremely short duration of the activity (essentially three instantaneous events within a day) and the robust monitoring and mitigation measures minimize the likelihood that auditory injury would occur. In short, although the new thresholds were not used in the calculation of take, we believe that the existing analysis adequately addresses the likely effects of the proposed action on ESA-listed marine mammals.

4 Status of ESA-listed Species

This section identifies the ESA-listed species that occur within the action area that may be affected by the proposed action (Table 3). It then summarizes the biology and ecology of those species and what is known about their life histories in the action area.

Table 3. Species listed under the Endangered Species Act under NMFS jurisdiction that may occur in the action area during the Air Force's 2016 proposed operational evaluations of live long-range strike weapons and other munitions mission.

Species	ESA Status	Critical Habitat	Recovery Plan
Marine Mammals – Cetaceans			
Blue Whale (*Balaenoptera musculus*)	E - 35 FR 18319	-- --	07/1998
Fin Whale (*Balaenoptera physalus*)	E - 35 FR 18319	-- --	75 FR 47538
Sei Whale (*Balaenoptera borealis*)	E - 35 FR 18319	-- --	-- --
Sperm Whale (*Physeter macrocephalus*)	E - 35 FR 18619	-- --	75 FR 81584
Main Hawaiian Islands Insular False Killer Whale DPS (*Pseudorca crassidens*)	E- 76 FR 70915	-- --	77 FR 71260
Pinnipeds			
Hawaiian Monk Seal (*Monachus schauinslandi*)	E - 41 FR 51611	-- --	72 FR 46966
Sea Turtles			

Species	ESA Status	Critical Habitat	Recovery Plan
Green Turtle (*Chelonia mydas*) - Central North Pacific DPS - East Indian-West Pacific DPS - Central West Pacific DPS - Southwest Pacific DPS - Central South Pacific DPS - East Pacific DPS	T - 81 FR 20057	-- --	63 FR 28359
Hawksbill Turtle (*Eretmochelys imbricata*)	E - 35 FR 8491	-- --	63 FR 28359
Loggerhead Turtle (*Caretta caretta*) – North Pacific Ocean DPS	E - 76 FR 58868	-- --	63 FR 28359
Olive Ridley Turtle (*Lepidochelys olivacea*) - Breeding populations on the Pacific coast of Mexico - All other populations	E – 43 FR 32800 T – 43 FR 32800	-- --	63 FR 28359
Leatherback Turtle (*Dermochelys coriacea*)	E – 35 FR 8491	-- --	63 FR 28359

4.1 ESA-listed Species Not Likely to be Adversely Affected

As described in the *Approach to the Assessment*, NMFS uses two criteria to identify those endangered or threatened species or critical habitat that are not likely to be adversely affected by the various proposed activities. The first criterion was exposure or some reasonable expectation of a co-occurrence between one or more stressors associated with the Air Force's activities and a particular listed species or designated critical habitat. If we conclude that an ESA-listed species or designated critical habitat is not likely to be exposed to the activities, we must also conclude that the species or critical habitat is not likely to be adversely affected by those activities. The second criterion is the probability of a response given exposure. An ESA-listed species or designated critical habitat that is exposed to a potential stressor but is likely to be unaffected by the exposure is also not likely to be adversely affected by the proposed action. We applied these criteria to the ESA-listed species in Table 1, and we summarize our results below.

An action warrants a "may affect, not likely to be adversely affected" finding when its effects are wholly *beneficial, insignificant* or *discountable*. *Beneficial* effects have an immediate positive effect without any adverse effects to the species or habitat. Beneficial effects are usually discussed when the project has a clear link to the ESA-listed species or its specific habitat needs, and consultation is required because the species may be affected.

Insignificant effects relate to the size or severity of the impact and include those effects that are undetectable, not measurable, or so minor that they cannot be meaningfully evaluated. Insignificant is the appropriate conclusion when plausible effects are going to happen, but will not rise to the level of constituting an adverse effect. That means the ESA-listed species may be expected to be affected, but not harmed or harassed.

Discountable effects are those that are extremely unlikely to occur. For an effect to be discountable, there must be a plausible adverse effect (i.e., a credible effect that could result from the action and that would be an adverse effect if it did impact an ESA-listed species), but it is very unlikely to occur.

4.1.1 Blue Whale

The blue whale (*Balaenoptera musculus*) is a baleen whale and is the largest animal on Earth, reaching a maximum body length as an adult in the Antarctic of about 33 m and weighing more than 150,000 kg. Blue whales inhabit all oceans and typically occur near the coast over the continental shelf, although they are also found in oceanic waters. Blue whales are highly mobile, and their migratory patterns are not well known (Perry et al. 1999; Reeves et al. 2004). Blue whales migrate toward the warmer waters of the subtropics in the fall to reduce energy costs, avoid ice entrapment, and reproduce (NMFS 1998).

In the North Pacific Ocean, blue whales have been recorded off the island of Oahu in the main Hawaiian Islands and off Midway Island in the western edge of the Hawaiian Archipelago (Barlow 2006; Northrop et al. 1971; Thompson and Friedl 1982b), although blue whales are rarely sighted in Hawaiian waters and have not been reported to strand in the Hawaiian Islands. Blue whales belonging to the western Pacific stock may feed in summer, south of the Aleutians and in the Gulf of Alaska, and migrate to wintering grounds in lower latitudes in the western Pacific and central Pacific, including Hawaii (Stafford et al. 2004; Watkins et al. 2000a; Watkins et al. 2000b; Watkins et al. 2000c). Bradford et al. (In Review) report a uniform density value for blue whales of 0.00005 animals/km^2 (CV = 1.09) that is applicable to the HRC in winter, spring, and fall.

Conclusion

As documented further in Section 6 of this opinion, the only stressor we determined would likely adversely affect ESA-listed species was acoustic stressors from the use of live explosive munitions. Other potential stressors associated with the proposed action (i.e., aircraft and weapons launch noise, ingestion of munitions, secondary stressors, direct physical strike) were determined to not likely adversely affect any ESA-listed species considered in this opinion. As described previously in Section 3.1 of this opinion, the Air Force's exposure analysis relied on density estimates from the NMSDD for the Pacific region. For blue whales, a density of 0.00005 was used for the period of time during which the action will occur (i.e., fall). Therefore, the Air Force's acoustic analysis resulted in zero blue whale exposures to acoustic stressors from live explosive munitions during 2016 activities. For this reason, we determined that the likelihood of a blue whale being exposed to acoustic stressors from the proposed action is discountable, and blue whales are not likely to be adversely affected by the proposed action.

4.1.2 Fin Whale

The fin whale (*Balaenoptera physalus*) is a cosmopolitan species of baleen whale (Gambell 1985a). Fin whales are the second-largest whale species by length. Fin whales are long-bodied and slender, with a prominent dorsal fin set about two-thirds of the way back on the body. Fin whales live 70-80 years (Kjeld 1982) and can be found in social groups of two to seven whales. Fin whales are distributed widely in every ocean except the Arctic Ocean. Fin whales undertake migrations from low-latitude winter grounds to high-latitude summer grounds and extensive longitudinal movements both within and between years (Mizroch et al. 1999a). Fin whales are sparsely distributed during November-April, from 60° N, south to the northern edge of the tropics, where mating and calving may take place (Mizroch et al. 1999a). However, fin whales have been sighted as far as 60° N throughout winter (Mizroch et al. 1999b). They are observed feeding in Hawaiian waters during mid-May, and their sounds have been recorded there during the autumn and winter (Balcomb 1987; Northrop et al. 1968; Shallenberger 1981b; Thompson and Friedl 1982a).

Fin whales were observed twice during a NMFS survey of waters within the Hawaiian EEZ in 2010 (Bradford et al. 2013), sighted five times in offshore waters during a NMFS 2002 survey in the same region, and sighted once during aerial surveys conducted between 1993 to 1998 (Barlow 2006; Carretta et al. 2010; Mobley Jr. et al. 2000). There are other known sightings from Kauai and Oahu, and a single stranding record from Maui, (Shallenberger 1981a); the most recent sighting was a single juvenile fin whale reported off Kauai in 2011 (Navy 2011). Based on sighting data and acoustic recordings, fin whales are likely to occur in Hawaiian waters mainly in fall and winter (Barlow 2006). No fin whales were sighted in the HRC during monitoring efforts from 2009 to 2012 (HDR 2012). Bradford et al. (In Review) report a uniform density value for fin whales of 0.00006 animals/km^2 (CV = 1.05) that is applicable to the HRC in winter, spring, and fall.

Conclusion

As documented further in Section 6 of this opinion, the only stressor we determined would likely adversely affect ESA-listed species was acoustic stressors from the use of live explosive munitions. Other potential stressors associated with the proposed action (i.e., aircraft and weapons launch noise, ingestion of munitions, secondary stressors, direct physical strike) were determined to not likely adversely affect any ESA-listed species considered in this opinion. As described previously in Section 3.1 of this opinion, the Air Force's exposure analysis relied on density estimates from the NMSDD for the Pacific region. For fin whales, a density of 0.00006 was used for the period of time during which the action will occur (i.e., fall). Therefore, the Air Force's acoustic analysis resulted in zero fin whale exposures to acoustic stressors from live explosive munitions during 2016 activities. For this reason, we determined that the likelihood of a fin whale being exposed to acoustic stressors from the proposed action is discountable, and fin whales are not likely to be adversely affected by the proposed action.

4.1.3 Sei Whale

Sei whales (pronounced "say" or "sigh"; *Balaenoptera borealis*) are members of the baleen whale family and are considered one of the "great whales" or rorquals. These large animals can reach lengths of about 12 to 18 m (40 to 60 ft) and weigh 45,000 kg (100,000 lbs). Sei whales have a long, sleek body that is dark bluish-gray to black in color and pale underneath. The sei whale occurs in all oceans of the world except the Arctic. The migratory pattern of this species is thought to encompass long distances from high-latitude feeding areas in summer to low-latitude breeding areas in winter; however, the location of winter areas remains largely unknown (Perry et al. 1999). Sei whales are often associated with deeper waters and areas along continental shelf edges (Hain et al. 1985). This general offshore pattern is disrupted during occasional incursions into shallower inshore waters (Waring et al. 2004). The species appears to lack a well-defined social structure and individuals are usually found alone or in small groups of up to six whales (Perry et al. 1999). When on feeding grounds, larger groupings have been observed (Gambell 1985b).

In the North Pacific Ocean, sei whales occur from the Bering Sea south to California (on the east) and the coasts of Japan and Korea (on the west). During the winter, sei whales are found from 20° to 23°N (Gambell 1985b; Masaki 1977). Saski et al. (2013) demonstrated that sei whale in the North Pacific are strongly correlated with sea surface temperatures between 13.1 to 16.8°C. Sei whales are infrequently observed near the HRC and are more abundant during the cool seasons (Barlow 2006). Bradford et al. (In Review) report a uniform density value for sei whales of 0.00016 animals/km^2 (CV = 0.90) that is applicable to the HRC in winter, spring, and fall.

Conclusion

As documented further in Section 6 of this opinion, the only stressor we determined would likely adversely affect ESA-listed species was acoustic stressors from the use of live explosive munitions. Other potential stressors associated with the proposed action (i.e., aircraft and weapons launch noise, ingestion of munitions, secondary stressors, direct physical strike) were determined to not likely adversely affect any ESA-listed species considered in this opinion. As described previously in Section 3.1 of this opinion, the Air Force's exposure analysis relied on density estimates from the NMSDD for the Pacific region. For sei whales, a density of 0.00016 was used for the period of time during which the action will occur (i.e., fall). Therefore, the Air Force's acoustic analysis resulted in zero sei whale exposures to acoustic stressors from live explosive munitions during 2016 activities. For this reason, we determined that the likelihood of a sei whale being exposed to acoustic stressors from the proposed action is discountable, and sei whales are not likely to be adversely affected by the proposed action.

4.1.4 Sperm Whale

Sperm whales (*Physeter macrocephalus*) are the largest of the odontocetes (toothed whales) and the most sexually dimorphic cetaceans, with males considerably larger than females. Adult females may grow to lengths of 11 m (36 feet) and weigh 13, 607 kg (15 tons). Adult males, however, reach about 16 m (52 feet) and may weigh as much as 40,823 kg (45 tons). The sperm whale is distinguished by its extremely large head, which takes up to 25 to 35 percent of its total body length. Sperm whales are distributed in all of the world's oceans, from equatorial to polar waters, and are highly migratory. During the winter, sperm whales migrate closer to equatorial waters (Kasuya and Miyashita 1988; Waring 1993) where adult males join them to breed. NMFS has divided sperm whales in the North Pacific into three stocks: the California/Oregon/Washington stock, the Hawaii stock, and the North Pacific Stock (largely animals from the Gulf of Alaska and the Bering Sea). The most recent stock assessment report indicates the best available abundance estimate for the Hawaii stock is 3,354 animals (Carretta et al. 2016).

Conclusion

As documented further in Section 6 of this opinion, the only stressor we determined would likely adversely affect ESA-listed species was acoustic stressors from the use of live explosive munitions. Other potential stressors associated with the proposed action (i.e., aircraft and weapons launch noise, ingestion of munitions, secondary stressors, direct physical strike) were determined to not likely adversely affect any ESA-listed species considered in this opinion. As described previously in Section 3.1 of this opinion, the Air Force's exposure analysis relied on density estimates from the NMSDD for the Pacific region. For sperm whales, a density of 0.00156 animals per km^2 was used for the period of time during which the action will occur (i.e., fall). The Air Force's acoustic analysis resulted in zero sperm whale exposures to acoustic stressors from live explosive munitions during 2016 activities. For this reason, we determined that the likelihood of a sperm whale being exposed to acoustic stressors from the proposed action at threshold levels above which impact criteria are reached (e.g., thresholds for mortality, permanent threshold shift, slight lung injury, behavioral harassment) is discountable and sperm whales are not likely to be adversely affected by the proposed action.

4.1.5 False Killer Whale – Main Hawaiian Islands Insular Distinct Population Segment

Main Hawaiian Islands (MHI) Insular false killer whales (*Pseudorca crassidens*) are large members of the dolphin family. Females reach lengths of 4.5 m (15 feet), while males are almost 6 m (20 feet). In adulthood, false killer whales can weigh approximately 700 kg (1,500 lbs).

The MHI insular false killer whale DPS occurs near the main Hawaiian Islands. The distribution of MHI insular false killer whales has been assessed using data from visual surveys and satellite tag data. Tagging data from seven groups of individuals tagged off the islands of Hawaii and Oahu indicate that the whales move rapidly and semi-regularly throughout the main Hawaiian Islands and have been documented as far as 112 km offshore over a total range of 82,800 km^2 (Baird et al. 2012a; Baird et al. 2012b). Three high-use areas were identified: (1) off the north half of Hawaii Island, (2) north of Maui and Molokaʻi, and (3) southwest of Lanaʻi (Baird et al. 2012a). However, note that limitations in the sampling suggest the range of the population is likely underestimated, and there are probably other high-use areas that have not been identified. For example, a single satellite track suggests the potential for MHI insular false killer whales to use habitat around the Northwestern Hawaiian Islands, where a separate false killer whale DPS tends to occur (Baird et al. 2012a). Other MHI insular false killer whales tagged off of Kauai circumnavigated Niʻihau and returned to the northwest side of the island of Kauai.

Photo identification studies also document that the animals regularly use both leeward and windward sides of the islands (Baird et al. 2005; Baird et al. 2012a; Baird et al. 2010; Forney et al. 2010; Oleson et al. 2010). Some individual false killer whales tagged off the island of Hawaii have remained around that island for extended periods (days to weeks), but individuals from all tagged groups eventually were found broadly distributed throughout the main Hawaiian Islands (Baird 2009; Forney et al. 2010). Individuals utilize habitat over varying water depths less than 50 m to greater than 4000 m (Baird et al. 2010). Inter-island movements may depend on the density and movement patterns of their prey species (Baird 2009). Evidence from tags and individual-identifying photographs suggests that the area between Kauai and Niʻihau near the PMRF is an area of range overlap between two or three populations of false killer whales, once of which is the MHI insular DPS. It appears that these waters may be at the far northwestern limit of the MHI insular DPS and the southeastern limit of the Northwestern Hawaiian Islands stock (Department of the Air Force 2016).

Conclusion

As documented further in Section 6 of this opinion, the only stressor we determined would likely adversely affect ESA-listed species was acoustic stressors from the use of live explosive munitions. Other potential stressors associated with the proposed action (i.e., aircraft and weapons launch noise, ingestion of munitions, secondary stressors, direct physical strike) were determined to not likely adversely affect any ESA-listed species considered in this opinion. As described previously in Section 3.1 of this opinion, the Air Force's exposure analysis relied on density estimates from the NMSDD for the Pacific region. For the MHI insular false killer whale DPS, a density of 0.00050 animals per km^2 was used for the period of time during which the action will occur (i.e., fall). The Air Force's acoustic analysis resulted in zero MHI insular false killer whale exposures to acoustic stressors from live explosive munitions during 2016 activities. For this reason, we determined that the likelihood of a MHI insular false killer whale being exposed to acoustic stressors from the proposed action at threshold levels above which impact criteria are reached (e.g., thresholds for mortality, permanent threshold shift, slight lung injury, behavioral harassment) is discountable, and false killer whales from the MHI insular DPS are not likely to be adversely affected by the proposed action.

4.1.6 Hawaiian Monk Seal

The Hawaiian monk seal has a silvery-grey colored back with lighter creamy coloration on the underside; newborns are black. Additional light patches and red and green tinged coloration from attached algae are common. The back of the animals may become darker with age, especially in males. Adults generally range in size from 170 to 205 kg (375 lbs to 450 lbs); females are slightly larger than males; pups are 16 kg (35 lbs) at birth. Monk seals grow to 2.1 to 2.3 m (7.0 to 7.5 ft) in length with females being slightly larger than males; pups are 1 m (3 feet) at birth. The lifespan is estimated at 25 to 30 years.

Hawaiian monk seals are found primarily on the Northwestern Hawaiian Islands, especially Nihoa, Necker, French Frigate Shoals, Pearl and Hermes Reef, Kure Atoll, Laysan, and Lisianski. Sightings on the main Hawaiian Islands have become more common in the past 15 years and monk seals have been born on the Islands of Kauai, Molokaʻi, Niʻihau, and Oahu

(Carretta et al. 2005; Johanos and Baker. 2004; Kenyon 1981). Midway was an important breeding rookery, but is now used by a small number of monk seals (Reeves et al. 1992). Hawaiian monk seals breed primarily at Laysan Island, Lisianski Island, and Pearl and Hermes Reefs (Tomich 1986). Monk seals have been reported on at least three occasions at Johnston Island over the past 30 years (not counting nine adult males that were translocated there from Laysan Island in 1984).

During Navy-funded marine mammal surveys from 2007 to 2012, there were 41 sightings of Hawaiian monk seals for a total of 58 individuals on (or near) Kauai, Ka‘ula, Ni‘ihau, Oahu, and Moloka‘I (HDR 2012). Forty-seven (81 percent) individuals were seen during aerial surveys, and eleven (19 percent) during vessel surveys. Monk seals were most frequently observed at Ni‘ihau. Fifty-two (88 percent) individual seals were observed hauled out, and six (10 percent) were in the water as deep as 800m. In addition, six seals were observed on the ledges of Kaula Islet during an aerial survey in 2013 (Normandeau Associates 2013).

The distribution, destinations, routes, food sources, and causes of monk seal movements when they are not traveling between islands are not well known (Johnson and Johnson 1979), but recent tagging studies have shown individuals sometimes travel between the breeding populations in the Northwest Hawaiian Islands. Based on one study, on average, 10 to 15 percent of the monk seals migrate among the northwestern Hawaiian Islands and the main Hawaiian Islands (Carretta et al. 2010). Another source suggests that 35.6 percent of the main Hawaiian Island seals travel between islands throughout the year (Littnan 2011).

Navy-funded tagging studies in the main Hawaiian Islands demonstrate that mean foraging trip distance and duration, as well as maximum dive depth are similar between seals (Littman 2011). However, there were multiple outlying data points for all seals that varied by individual home ranges. Excluding one seal (R012) extended pelagic foraging trip, none of the seals travelled more than 300 km per trip, and most travelled less than 50 km and remained within the 600-m depth contour near the MHI. The mean dive depth was 27.03 ± 44.97 m with a maximum of 529.4 m and a median depth of 14.4 m. The average dive duration was 5.006 ± 3.10 minutes with a median of 5.07 minutes with 28 percent of the time between dives was spent at the surface. Although foraging trip distances and durations were similar among seals, there were high levels of individual variation in where the seals travelled (Wilson and D’Amico 2012).

Conclusion
As documented further in Section 6 of this opinion, the only stressor we determined would likely adversely affect ESA-listed species was acoustic stressors from the use of live explosive munitions. Other potential stressors associated with the proposed action (i.e., aircraft and weapons launch noise, ingestion of munitions, secondary stressors, direct physical strike) were determined to not likely adversely affect any ESA-listed species considered in this opinion. As described previously in Section 3.1 of this opinion, the Air Force’s exposure analysis relied on density estimates from the NMSDD for the Pacific region. For Hawaiian monk seals, a density of 0.00003 animals per km^2 was used for the period of time during which the action will occur (i.e.,

fall). The Air Force's acoustic analysis resulted in zero Hawaiian monk seal exposures to acoustic stressors from live explosive munitions during 2016 activities. For this reason, we determined that the likelihood of a Hawaiian monk seal being exposed to acoustic stressors from the proposed action at threshold levels above which impact criteria are reached (e.g., thresholds for mortality, permanent threshold shift, slight lung injury, behavioral harassment) is discountable, and Hawaiian monk seals are not likely to be adversely affected by the proposed action.

4.1.7 Hawksbill Sea Turtle

The hawksbill turtle (*Eretmochelys imbricata*) is a small to medium-sized sea turtle; adults typically range between 65 and 90 cm (26 to 35 in) in carapace length and weigh around 80 kg (176 lb) (Witzell 1983). Hawksbills are distinguished from other sea turtles by their hawk-like beaks, posteriorly overlapping carapace scutes, and two pairs of claws on their flippers (NMFS and USFWS 1993).

Hawksbill sea turtles occur in tropical and subtropical seas of the Atlantic, Pacific and Indian Oceans. Hawksbill sea turtles occupy different habitats depending on their life history stage. After entering the sea, hawksbill turtles occupy pelagic waters and occupy weed lines that accumulate at convergence points. When they grow to about 20 to 25 cm carapace length, hawksbill turtles re-enter coastal waters where they inhabit and forage in coral reefs as juveniles, sub-adults and adults. Hawksbill sea turtles also occur around rocky outcrops and high energy shoals, where sponges grow and provide forage, and they are known to inhabit mangrove-fringed bays and estuaries, particularly along the eastern shore of continents where coral reefs are absent. Hatchling and early juvenile hawksbills have also been found in the open ocean, in floating mats of seaweed (Musick and Limpus 1997). Although information about foraging areas is largely unavailable due to research limitations, juvenile and adult hawksbills may also be present in open ocean environments (NMFS and USFWS 2007a).

Hawksbills are mostly found in the coastal waters of the eight main islands of the Hawaiian Island chain. Stranded or injured hawksbills are occasionally found in the Northwestern Hawaiian Islands (Parker et al. 2009). Hawksbills are the second-most-common species in the offshore waters of the Hawaiian Islands, yet they are far less abundant than green turtles (Chaloupka et al. 2008c). The lack of hawksbill sightings during aerial and shipboard surveys likely reflects the species' small size and difficulty in identifying them from a distance.

Hawksbills have been captured in Kiholo Bay and Kau (Hawaii), Palaau (Moloka‘i), and Makaha (Oahu). Strandings have been reported in Kaneohe and Kahana Bays (Oahu) and throughout the main Hawaiian Islands (Eckert 1993b; NMFS and USFWS 1998b). Hawksbills primarily nest on the southeastern beaches of the Island of Hawaii. Since 1991, 81 nesting female hawksbills have been tagged on the island of Hawaii at various locations. This number does not include nesting females from Maui or Moloka‘i, which would add a small number to the total. Post-nesting hawksbills have been tracked moving between Hawaii and Maui over the deep waters of the Alenuihaha Channel (Parker et al. 2009). Only two hawksbills have ever been sighted in the Pearl Harbor entrance channel, and none have been sighted inside the harbor (Smith 2010).

Research suggests that movements of hawksbill turtles are relatively short, with individuals generally migrating through shallow coastal waters and few deep-water transits between the islands. Nine hawksbill turtles were tracked within the Hawaiian Islands using satellite telemetry. Turtles travelled from 89 to 346 km (55 to 215 mi) and took between 5 and 18 days to complete the trip from nesting to foraging areas (Parker et al. 2009).

Conclusion

As documented further in Section 6 of this opinion, the only stressor we determined would likely adversely affect ESA-listed species was acoustic stressors from the use of live explosive munitions. Other potential stressors associated with the proposed action (i.e., aircraft and weapons launch noise, ingestion of munitions, secondary stressors, direct physical strike) were determined to not likely adversely affect any ESA-listed species considered in this opinion. As described previously in Section 3.1 of this opinion, the Air Force's exposure analysis relied on density estimates from the NMSDD for the Pacific region. As documented further in section 3.1 of this opinion, due to the relative scarcity of some species and the lack of density estimates for sea turtles associated with open ocean habitats such as the BSURE area, the Air Force assessed the impacts of the 2016 Long Range Strike Weapon Systems Evaluation Program mission using a single guild (Pacific Sea Turtles), which combines all sea turtle species. For Pacific sea turtles, a density of 0.00429 animals per km^2 was used for the period of time during which the action will occur (i.e., fall). The Air Force's acoustic analysis resulted in one Pacific sea turtle exposure to acoustic stressors from live explosive munitions during 2016 activities that would be expected to result in TTS (see section 6.4.1). However, as also documented in section 3.1 of this opinion, available information suggests that the majority of the sea turtles within the PMRF (and the majority of the sea turtles within the Pacific sea turtle guild) would be green sea turtles from the Central North Pacific DPS. Therefore, we assume that the one instance of TTS would likely happen to a Central North Pacific DPS green sea turtle. For this reason, we determined that the likelihood of a hawksbill sea turtle being exposed to acoustic stressors from the proposed action at threshold levels above which impact criteria are reached (e.g., thresholds for mortality, permanent threshold shift, slight lung injury, behavioral harassment) is discountable, and hawksbill sea turtles are not likely to be adversely affected by the proposed action.

4.1.8 Loggerhead Sea Turtle – North Pacific Ocean DPS

Loggerhead turtles (*Caretta caretta*) were named for their relatively large heads, which support powerful jaws and enable them to feed on hard-shelled prey, such as whelks and conch. The carapace (top shell) is slightly heart-shaped and reddish-brown in adults and sub-adults, while the plastron (bottom shell) is generally a pale yellowish color. The neck and flippers are usually dull brown to reddish brown on top and medium to pale yellow on the sides and bottom. Flippers are dark gray to brown above with white to white-gray margins. The coloration of the plastron is generally yellowish to tan. At emergence, hatchlings average 45 mm (1.8 in) in length and weigh approximately 20 g (0.04 lbs).

Loggerheads are circumglobal, inhabiting continental shelves, bays, estuaries, and lagoons in temperate, subtropical, and tropical waters. Major nesting grounds are generally located in temperate and subtropical regions, with scattered nesting in the tropics (NMFS and USFWS 1998d). Within the North Pacific Ocean, loggerhead nesting has only been documented in Japan (Kamezaki et al. 2003). Adult loggerheads are known to make considerable migrations from nesting beaches to foraging grounds (TEWG 2009); and evidence indicates turtles entering the benthic environment undertake routine migrations along the coast that are limited by seasonal water temperatures. Small juveniles are found in pelagic waters and the transition from oceanic to neritic juvenile stages can involve trans-oceanic migrations (Bowen et al. 2004).

Conclusion

As documented further in Section 6 of this opinion, the only stressor we determined would likely adversely affect ESA-listed species was acoustic stressors from the use of live explosive munitions. Other potential stressors associated with the proposed action (i.e., aircraft and weapons launch noise, ingestion of munitions, secondary stressors, direct physical strike) were determined to not likely adversely affect any ESA-listed species considered in this opinion. As described previously in Section 3.1 of this opinion, the Air Force's exposure analysis relied on density estimates from the NMSDD for the Pacific region. As documented previously in section 3.1 of this opinion, due to the relative scarcity of some species and the lack of density estimates for sea turtles associated with open ocean habitats such as the BSURE area, the Air Force assessed the impacts of the 2016 Long Range Strike Weapon Systems Evaluation Program mission using a single guild (Pacific Sea Turtles), which combines all sea turtle species. For Pacific sea turtles, a density of 0.00429 animals per km^2 was used for the period of time during which the action will occur (i.e., fall). The Air Force's acoustic analysis resulted in one Pacific sea turtle exposure to acoustic stressors from live explosive munitions during 2016 activities that would be expected to result in TTS (see section 6.4.1). However, as also documented in section 3.1 of this opinion, available information suggests that the majority of the sea turtles within the PMRF (and the majority of the sea turtles within the Pacific sea turtle guild) would be green sea turtles from the Central North Pacific DPS. Therefore, we assume that the one instance of TTS would likely occur to a Central North Pacific DPS green sea turtle. For this reason, we determined that the likelihood of a loggerhead sea turtle being exposed to acoustic stressors from the proposed action at threshold levels above which impact criteria are reached (e.g., thresholds for mortality, permanent threshold shift, slight lung injury, behavioral harassment) is discountable, and loggerhead sea turtles from the North Pacific Ocean DPS are not likely to be adversely affected by the proposed action.

4.1.9 Olive Ridley Sea Turtle

The olive ridley turtle (*Lepidochelys olivacea*) is a small to medium-sized sea turtle; adults typically range between 55 and 80 cm (22 to 31 in) in carapace length and weigh around 45 kg

(100 lb). They are olive/grayish-green (darker in the Atlantic than in the Pacific) with a heart-shaped top shell (carapace) with 5 to 9 pairs of costal "scutes" with 1 to 2 claws on their flippers; hatchlings emerge mostly black with a greenish hue on the sides.

Olive ridley sea turtles occur in tropical and subtropical seas in the Pacific, Atlantic, and Indian Oceans and occasionally seen in the Caribbean Sea. While Pacific ridley turtles have a generally tropical to subtropical range, individual turtles have been reported as far as the Gulf of Alaska (Hodge and Wing 2000). Olive ridley turtles nest along continental margins and oceanic islands. The post-nesting olive ridleys are known to traverse thousands of kilometers in deep oceanic waters, ranging from Mexico to Peru, and more than 3,000 kilometers out into the central Pacific (Plotkin 2007). Although they are the most abundant north Pacific sea turtle, surprisingly little is known of the oceanic distribution and critical foraging areas of Pacific ridley turtles. Most records of olive ridley turtles are from protected, shallow marine waters. Nevertheless, olive ridley turtles have also been observed in the open ocean. Since olive ridley turtles throughout the eastern Pacific Ocean depend on rich upwelling areas off South America for food, Pacific ridley turtles sighted offshore may have been foraging. Genetic information from the Hawaii-based longline fishery indicates that Olive Ridley sea turtles from breeding populations in the eastern (endangered populations) and western Pacific (threatened populations) mix in waters around Hawaii (NMFS 2005).

Conclusion

As documented further in Section 6 of this opinion, the only stressor we determined would likely adversely affect ESA-listed species was acoustic stressors from the use of live explosive munitions. Other potential stressors associated with the proposed action (i.e., aircraft and weapons launch noise, ingestion of munitions, secondary stressors, direct physical strike) were determined to not likely adversely affect any ESA-listed species considered in this opinion. As described previously in Section 3.1 of this opinion, the Air Force's exposure analysis relied on density estimates from the NMSDD for the Pacific region. As documented previously in section 3.1 of this opinion, due to the relative scarcity of some species and the lack of density estimates for sea turtles associated with open ocean habitats such as the BSURE area, the Air Force assessed the impacts of the 2016 Long Range Strike Weapon Systems Evaluation Program mission using a single guild (Pacific Sea Turtles), which combines all sea turtle species. For Pacific sea turtles, a density of 0.00429 animals per km^2 was used for the period of time during which the action will occur (i.e., fall). The Air Force's acoustic analysis resulted in one Pacific sea turtle exposure to acoustic stressors from live explosive munitions during 2016 activities that would be expected to result in TTS (see section 6.4.1). However, as also documented in section 3.1 of this opinion, available information suggests that the majority of the sea turtles within the PMRF (and the majority of the sea turtles within the Pacific sea turtle guild) would be green sea turtles from the Central North Pacific DPS. Therefore, we assume that the one instance of TTS would likely occur to a Central North Pacific DPS green sea turtle. For this reason, we determined that the likelihood of an olive ridley sea turtle (from the endangered populations that nest in the eastern Pacific or the threatened populations that nest in the western Pacific) being exposed to acoustic stressors from the proposed action at threshold levels above which impact criteria are reached (e.g., thresholds for mortality, permanent threshold shift, slight lung injury, behavioral harassment) is discountable, and olive ridley sea turtles are not likely to be adversely affected by the proposed action.

4.1.10 Leatherback Sea Turtle

The leatherback turtle (*Dermochelys coriacea*) is the largest turtle and the largest living reptile in the world. Mature males and females can be as long as 2 m (6.5 feet) and weigh almost 900 kg (2000 lbs). The leatherback is the only sea turtle that lacks a hard, bony shell. Leatherbacks lack the crushing chewing plates characteristic of sea turtles that feed on hard-bodied prey (Pritchard 1971). Instead, they have pointed tooth-like cusps and sharp edged jaws that are perfectly adapted for a diet of soft-bodied pelagic (open ocean) prey, such as jellyfish and salps.

Leatherback turtles are widely distributed throughout the oceans of the world. The species is found in four main regions of the world: the Pacific, Atlantic, and Indian Oceans, and the Caribbean Sea. In the Pacific Ocean, leatherback turtles have the most extensive range of any living reptile and have been reported in all pelagic waters of the Pacific between 71°N and 47°S latitude and in all other major pelagic ocean habitats (NMFS and USFWS 1998a). Leatherback turtles lead a completely pelagic existence, foraging widely in temperate waters except during the nesting season, when gravid females return to tropical beaches to lay eggs.

Few quantitative data are available concerning the seasonality, abundance, or distribution of leatherbacks in the central northern Pacific Ocean. Satellite tracking studies and occasional incidental captures of the species in the Hawaii-based longline fishery indicate that deep ocean waters are the preferred habitat of leatherback turtles in the central Pacific Ocean (NMFS and USFWS 2007b). The primary migration corridors for leatherbacks are across the North Pacific Subtropical Gyre, with the eastward migration route possibly to the north of the westward migration.

The primary data available for leatherbacks in the North Pacific Transition Zone come from longline fishing bycatch reports, as well as several satellite telemetry data sets (Benson et al. 2007). Leatherbacks from both the eastern and western Pacific Ocean nesting populations migrate to northern Pacific Ocean foraging grounds, where longline fisheries operate (Dutton et al. 1998). Leatherbacks from nesting beaches in the Indo-Pacific region have been tracked migrating thousands of kilometers through the North Pacific Transition Zone to summer foraging grounds off the coast of northern California (Benson et al. 2007). Genetic sampling of 18 leatherback turtles caught in the Hawaiian longline fishery indicated that about 94 percent originated from western Pacific Ocean nesting beaches (NMFS and USFWS 2007b). The remaining six percent of the leatherback turtles found in the open ocean waters north and south of the Hawaiian Islands represent nesting groups from the eastern tropical Pacific Ocean.

Leatherback turtles are regularly sighted by fishermen in offshore waters surrounding the Hawaiian Islands, generally beyond the 1,158 m (3,800 ft) contour, and especially at the southeastern end of the island chain and off the northern coast of Oahu (Balazs 1995). Leatherbacks encountered in these waters, including those caught accidentally in fishing operations, may be migrating through the Insular Pacific-Hawaiian Large Marine Ecosystem (NMFS and USFWS 1998a). Sightings and reported interactions with the Hawaii longline fishery commonly occur around seamount habitats above the Northwestern Hawaiian Islands (from 35° N to 45° N and 175° W to 180° W) (Skillman and Balazs 1992; Skillman and Kleiber 1998).

The leatherback turtle occurs within the entire Insular Pacific-Hawaiian Large Marine Ecosystem beyond the 101 m (330 ft) isobath; inshore of this isobath is the area of rare leatherback occurrence. Incidental captures of leatherbacks have also occurred at several offshore locations around the main Hawaiian Islands (McCracken 2000). Although leatherback bycatches are common off the island chain, leatherback-stranding events on Hawaiian beaches are uncommon. Since 1982, only five leatherbacks have stranded in the Hawaiian Islands (Chaloupka et al. 2008a). Leatherbacks were not sighted during any of the aerial surveys, all of which took place over waters lying close to the Hawaiian shoreline. Leatherbacks were also not sighted during any of the NMFS shipboard surveys; their deep diving capabilities and long submergence times reduce the probability that observers could spot them during marine surveys. One leatherback turtle was observed along the Hawaiian shoreline during monitoring surveys in 2006 (Rivers 2011).

Conclusion

As documented further in Section 6 of this opinion, the only stressor we determined would likely adversely affect ESA-listed species was acoustic stressors from the use of live explosive munitions. Other potential stressors associated with the proposed action (i.e., aircraft and weapons launch noise, ingestion of munitions, secondary stressors, direct physical strike) were determined to not likely adversely affect any ESA-listed species considered in this opinion. As described previously in Section 3.1 of this opinion, the Air Force’s exposure analysis relied on density estimates from the NMSDD for the Pacific region. As documented previously in section 3.1 of this opinion, due to the relative scarcity of some species and the lack of density estimates for sea turtles associated with open ocean habitats such as the BSURE area, the Air Force assessed the impacts of the 2016 Long Range Strike Weapon Systems Evaluation Program mission using a single guild (Pacific Sea Turtles), which combines all sea turtle species. For Pacific sea turtles, a density of 0.00429 animals per km^2 was used for the period of time during which the action will occur (i.e., fall). The Air Force’s acoustic analysis resulted in one Pacific sea turtle exposure to acoustic stressors from live explosive munitions during 2016 activities that would be expected to result in TTS (see section 6.4.1). However, as also documented in section 3.1 of this opinion, available information suggests that the majority of the sea turtles within the PMRF (and the majority of the sea turtles within the Pacific sea turtle guild) would be green sea turtles from the Central North Pacific DPS. Therefore, we assume that the one instance of TTS would likely occur to a Central North Pacific DPS green sea turtle. For this reason, we determined that the likelihood of a leatherback sea turtle being exposed to acoustic stressors from the proposed action at threshold levels above which impact criteria are reached (e.g., thresholds for mortality, permanent threshold shift, slight lung injury, behavioral harassment) is discountable, and leatherback sea turtles are not likely to be adversely affected by the proposed action.

4.1.11 Green sea turtle – East Indian-West Pacific, Central West Pacific, Southwest Pacific, Central South Pacific, Southwest Pacific, Central South Pacific, and East Pacific DPSs

On April 6, 2016 NMFS published a final rule to list 11 DPSs of green sea turtles as threatened or endangered under the ESA (Figure 3; 81 FR 20057).

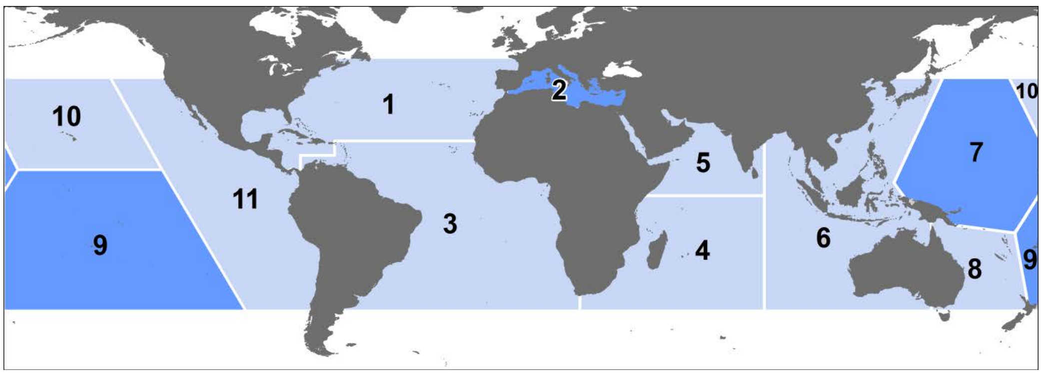


Figure 3. Threatened (light blue) and endangered (dark blue) green turtle Distinct Population Segments : 1) North Atlantic, 2) Mediterranean, 3) South Atlantic, 4) Southwest Indian, 5) North Indian, 6) East Indian-West Pacific, 7) Central West Pacific, 8) Southwest Pacific, 9) Central South Pacific, 10) Central North Pacific, and 11) East Pacific (Map source: 81 FR 20057).

For general green sea turtle distribution and life history information, see section 4.2.1 of this opinion. As documented in Section 3.1, the action area is entirely contained within the DPS delineation of the Central North Pacific DPS. While some green turtles from other DPSs could occur within the action area during for foraging and migration (e.g., East Pacific DPS, Central West Pacific, Central South Pacific), we would expect the vast majority of green turtles within the action area to be from the Central North Pacific DPS. Green sea turtles from DPSs within the Pacific Ocean other than the Central North Pacific DPS (i.e., East Indian-West Pacific DPS, Central West Pacific DPS, Southwest Pacific DPS, Central South Pacific DPS, Southwest Pacific DPS, Central South Pacific DPS, and East Pacific DPS) could rarely occur in the action area.

Conclusion
As documented further in Section 6 of this opinion, the only stressor we determined would likely adversely affect ESA-listed species was acoustic stressors from the use of live explosive munitions. Other potential stressors associated with the proposed action (i.e., aircraft and weapons launch noise, ingestion of munitions, secondary stressors, direct physical strike) were

determined to not likely adversely affect any ESA-listed species considered in this opinion. As described previously in Section 3.1 of this opinion, the Air Force's exposure analysis relied on density estimates from the NMSDD for the Pacific region. As documented previously in section 3.1 of this opinion, due to the relative scarcity of some species and the lack of density estimates for sea turtles associated with open ocean habitats such as the BSURE area, the Air Force assessed the impacts of the 2016 Long Range Strike Weapon Systems Evaluation Program mission using a single guild (Pacific Sea Turtles), which combines all sea turtle species. For Pacific sea turtles, a density of 0.00429 animals per km^2 was used for the period of time during which the action will occur (i.e., fall). The Air Force's acoustic analysis resulted in one Pacific sea turtle exposure to acoustic stressors from live explosive munitions during 2016 activities that would be expected to result in TTS (see section 6.4.1). However, as also documented in section 3.1 of this opinion, available information suggests that the majority of the sea turtles within the PMRF (and the majority of the sea turtles within the Pacific sea turtle guild) would be green sea turtles from the Central North Pacific DPS. Therefore, we assume that the one instance of TTS would likely occur to a Central North Pacific DPS green sea turtle. For this reason, we determined that the likelihood of a green sea turtle from other Pacific Ocean DPSs (East Indian-West Pacific DPS, Central West Pacific DPS, Southwest Pacific DPS, Central South Pacific DPS, Southwest Pacific DPS, Central South Pacific DPS, and East Pacific DPS) being exposed to acoustic stressors from the proposed action at threshold levels above which impact criteria are reached (e.g., thresholds for mortality, permanent threshold shift, slight lung injury, behavioral harassment) is discountable, and green sea turtles from these DPSs are not likely to be adversely affected by the proposed action.

4.2 Species Likely to be Adversely Affected

This opinion examines the status of each species that would be affected by the proposed action. The status is determined by the level of risk that the ESA-listed species face, based on parameters considered in documents such as recovery plans, status reviews, and listing decisions. The species status section helps to inform the description of the species' current "reproduction, numbers, or distribution" as described in 50 CFR 402.02. More detailed information on the status and trends of these ESA-listed species, and their biology and ecology can be found in the listing regulations and critical habitat designations published in the Federal Register, status reviews, recovery plans, and on this NMFS Web site: http://www.nmfs.noaa.gov/pr/species/index.htm.

4.2.1 Green sea turtle – Central North Pacific DPS

Green turtles are distinguished by their smooth carapace with four pairs of costal scutes, a single pair of elongated prefrontal scales between the eyes, and a serrated upper and lower jaw (Figure 4) (Carr 1952; Hirth 1971; Pritchard and Trebbau 1984). Green turtles are the largest of all the hard-shelled sea turtles, but have a comparatively small head. Adults have a light to dark brown carapace with shades of olive, grey, green and black in starburst or irregular patterns (Lagueux 2001), and their plastron (bottom shell) is yellowish white. They can exceed one meter in length and 100 kg in body mass (NMFS and USFWS 1998c). Eastern Pacific green turtles are conspicuously smaller and lighter than their counterparts in the central and western Pacific. Nesting females at French Frigate Shoals in the Northwestern Hawaii Islands average 92 cm in straight carapace length (Balazs 1980), while at the Olimarao Atoll in Yap (western Pacific), females average 104 cm in curved carapace length (Kolinski 1991). Hatchlings average about 4.7 to 5.4 cm in carapace length and 22 to 31 g in weight (Márquez 1990).

Figure 4. Green sea turtle (*Chelonia mydas*). Credit: Andy Bruckner, NOAA.

Nesting in the Hawaiian Islands occurs from May to September, peaking in early June. Females lay an average of two, but up to six nests per season with a mean of 104 eggs per clutch (Balazs 1979). More than 90 percent of all Hawaiian Island green turtle breeding and nesting occurs at French Frigate Shoals in the Northwestern Hawaiian Islands, the largest nesting colony in the central Pacific Ocean, where 200 to 700 females nest each year (NMFS and USFWS 2007a). In the spring of 2010, two green turtles nested at the Pacific Missile Range Facility for the first time in more than a decade, with successful hatching in August 2010 (DON 2010).

Green sea turtles are highly mobile and undertake complex movements through geographically disparate habitats during their lifetimes (Musick and Limpus 1997; Plotkin 2003). After hatchlings depart the beach for pelagic areas, green turtles reside in a variety of marine habitats for 40 or more years (Limpus and Chaloupka 1997), but they spend the majority of their lives in coastal foraging grounds. When juveniles reach about 20 to 25 cm in carapace length, they leave pelagic habitats and enter coastal foraging grounds (Bjorndal 1997). Adult females return to the same beach from which they hatched to lay eggs (Carr et al. 1978; Meylan et al. 1990). Hawaiian green turtles monitored through satellite transmitters were found to travel more than 1,100 km from their nesting beach in the French Frigate Shoals, south and southwest against prevailing currents to numerous distant foraging grounds within the 2,400-km span of the archipelago (Balazs et al. 1994; Balazs and Ellis 1996). Tag returns of eastern Pacific green turtles establish these turtles travel more than 1,000 km between their foraging and nesting grounds. In 1990, observers documented green turtles 1600 to 3200 km from the shore (Eckert 1993a).

4.2.1.1 Distribution

Green sea turtles are distributed circumglobally, occurring primarily in tropical waters, and to a lesser extent, subtropical and temperate waters. Green turtles appear to prefer waters that remain around 20 °C in the coldest month (Hirth 1971), but may be found considerably north of these areas during warm water events, such as El Niño.

The green turtle is the most common sea turtle species in Hawaii, occurring in the coastal waters of the main Hawaiian Islands throughout the year and seasonal migrations to the North-western Hawaiian Islands to reproduce. The first recorded green turtle nest on the Island of Hawaii occurred in 2011. Green sea turtles are found in inshore waters around all of the main Hawaiian Islands and Nihoa Island, where reefs, their preferred habitats for feeding and resting, are most abundant. A large foraging population resides in and returns to the shallow waters surrounding the main Hawaiian Islands (especially around Maui and Kauai), where they are known to come ashore at several locations on all eight of the main Hawaiian Islands for basking or nesting. They are also common in an oceanic zone surrounding the Hawaiian Islands. This area is frequently inhabited by adults migrating to the North-western Hawaiian Islands to reproduce during the summer and by ocean-dwelling individuals that have yet to settle into coastal feeding grounds of the main Hawaiian Islands. Farther offshore, green turtles occur in much lower numbers and densities.

As documented in Section 3.1, the action area is entirely contained within the DPS delineation of the Central North Pacific DPS. The range of the Central North Pacific DPS covers the Hawaiian Archipelago and Johnston Atoll. It is bounded by a four-sided polygon with open ocean extents reaching to 41° N, 169° E in the northwest corner, 41° N, 143° W in the northeast, 9° N, 125° W in southeast, and 9° N, 175° W in the southwest. The Hawaiian Archipelago is the most geographically isolated island group on the planet. From 1965 to 2013, 17,536 green turtles were tagged, including all post-pelagic size classes from juveniles to adults. With only three exceptions, the 7,360 recaptures of these tagged turtles have been made within the Hawaiian Archipelago. The three outliers involved a recovery in Japan, one in the Marshall Islands and one in the Philippines.

More than 90 percent of all Hawaiian Island green turtle breeding and nesting occurs at French Frigate Shoals in the North-western Hawaiian Islands, the largest nesting colony in the central Pacific Ocean, where 200 to 700 females nest each year (NMFS and USFWS 2007a). A large foraging population resides in and returns to the shallow waters surrounding the main Hawaiian Islands (especially around Maui and Kauai), where they are known to come ashore at several locations on all eight of the main Hawaiian Islands for basking or nesting.

4.2.1.2 Habitat

Green sea turtles occur preferentially in drift lines or surface current convergences, probably because of the prevalence of cover and higher prey densities that associate with flotsam. For example, in the western Atlantic Ocean, drift lines commonly containing floating *Sargassum* spp. are capable of providing juveniles with shelter (NMFS and USFWS 1998c). Underwater resting sites include coral recesses, the underside of ledges, and sand bottom areas that are relatively free of strong currents and disturbance. Available information indicates that green turtle resting areas are near feeding areas (Bjorndal and Bolten 2000). Strong site fidelity appears to be a characteristic of juveniles green sea turtles along the Pacific Baja coast (Senko et al. 2010). Recent tagging data from off the northwestern coast of Saipan and the western coast of Tinian also indicate strong site fidelity (Jones and Houtan 2014).

4.2.1.3 Feeding

Adult green turtles are unique among sea turtles in that they are herbivorous, feeding primarily on sea grasses and algae. This diet is thought to give them greenish-colored fat, from which they take their name. While offshore and sometimes in coastal areas, green sea turtles are not obligate herbivores but consume invertebrates such as jellyfish, sponges, sea pens, and pelagic prey (Hatase et al. 2006b; Heithaus and Dill 2002; Seminoff et al. 2002). A shift to a more herbivorous diet occurs when individuals move into neritic habitats. This transition occurs rapidly starting at 30 cm carapace length, but animal prey continues to be an important nutritional component until individuals reach about 62 cm (Cardona et al. 2010). Localized movement in foraging areas can be strongly influenced by tidal movement (Berkson 1967).

Green turtles depend on shallow foraging grounds with sufficient benthic vegetation. Therefore, direct destruction of foraging areas due to dredging, boat anchorage, deposition of spoil, and siltation may have considerable effects on the distribution of foraging green turtles (Coston-Clements and Hoss 1983; Williams 1988). Eutrophication, heavy metals, radioactive elements, and hydrocarbons all may reduce the extent, quality, and productivity of foraging grounds as well (Frazier 1980; McKenzie et al. 1999; Storelli and Marcotrigiano 2003). Various types of marine debris such as plastics, oil, and tar tend to collect on pelagic drift lines that young green turtles inhabit (Carr 1987; Moore et al. 2001) and can lead to death through ingestion (Balazs 1985; Bjorndal et al. 1994a).

4.2.1.4 Migration and movement

Green sea turtles are highly mobile and undertake complex movements through geographically disparate habitats during their lifetimes (Musick and Limpus 1997; Plotkin 2003). After hatchlings depart the beach for pelagic areas, green turtles reside in a variety of marine habitats for 40 or more years (Limpus and Chaloupka 1997), but they spend the majority of their lives in coastal foraging grounds. These areas include open coastline and protected bays and lagoons. When juveniles reach about 20 to 25 cm in carapace length, they leave pelagic habitats and enter coastal foraging grounds (Bjorndal 1997).

Adult females return to the same beach from which they hatched to lay their eggs (Carr et al. 1978; Meylan et al. 1990). Hawaiian green turtles monitored through satellite transmitters were found to travel more than 1,100 km from their nesting beach in the French Frigate Shoals, south and southwest against prevailing currents to distant foraging grounds around the 2,400-km span of the archipelago (Balazs et al. 1994; Balazs and Ellis 1996). Tag returns of eastern Pacific green turtles establish that these turtles travel more than 1,000 km between foraging and nesting grounds. In 1990, observers documented green turtles 1600 to 3200 km from shore (Eckert 1993a).

4.2.1.5 Hearing

Little information exists regarding the impacts of underwater explosives on sea turtles. The effects of explosions on turtles are usually inferred from documented effects to other vertebrates including humans, marine mammals, and fishes. However, extrapolating these effects to sea turtles may not be reliable. Potential impacts include non-injurious and injurious effects. Non-injurious effects include acoustic annoyance, tactile detection, or physical discomfort. Injurious effects include non-lethal and lethal injury (Viada et al. 2008).

The ear anatomy of sea turtles has been thoroughly discussed (Bartol et al. 1999a; Lenhardt et al. 1985; Moein Bartol and Musick 2003; Moein 1994; Wever 1978). Most reptiles demonstrate three principal divisions of the ear: the outer, middle, and inner ear. The external ear for sea turtles is absent (Wever 1978). The middle ear is well-developed and is sound-receptive and sound-conductive and is the most important to evaluate because of the air-filled chamber called the tympanic cavity. The basilar papilla serves as the auditory sense organ within the inner ear (Wever 1978).

The organ most sensitive to the primary effects of a blast wave is the auditory apparatus. A few studies have been conducted to measure green turtle hearing sensitivity, each using a slightly different methodology. Ridgeway et al. (1969) studied the auditory evoked potentials of three green turtles (in air and through direct mechanical stimulation of the inner ear) and tested a range of 30 to 2000 Hz. Results revealed that green sea turtles detected limited sound frequencies (200 to 700 Hz) with maximum sensitivity of about 400 Hz and rapid declines for tones at lower and higher frequencies. They reported an upper limit for cochlear potentials without injury of 2000 Hz and a practical limit of about 1000 Hz. Bartol and Ketten (2006) measured auditory brainstem responses (short latency auditory evoked potentials) to aerial tones in partially submerged green turtles and documented hearing between 100 and 800 Hz, with maximum sensitivity between 600 and 700 Hz in Atlantic juvenile greens, and100 and 500 Hz with maximum sensitivity between 200 and 400 Hz in Pacific sub-adult greens (Moein Bartol and Ketten 2006). Dow Piniak et al. (2012) recorded auditory evoked potential in response to both aerial and underwater acoustic stimuli. Green turtles detected acoustic stimuli in both media, responding to underwater signals between 50 and 1,600 Hz (turtles completely submerged) and aerial signals between 50 and 800 Hz, with maximum sensitivity between 200 and 400 Hz underwater and 300 and 400 Hz in air (Piniak et al. 2012).

These studies provide the reasonable assumption that the sea turtle auditory apparatus is sensitive to sounds produced by underwater explosions. A momentary startle response or temporary disorientation could result from detonations of low intensity or of sufficient distance to be detected, but not injurious (Viada et al. 2008). Rupture of the tympanic membrane, or the tympanum in the case of sea turtles, while not necessarily a serious or life-threatening injury, may lead to permanent hearing loss (Ketten 1995; Ketten 1998). No data exist that correlate the sensitivity of the sea turtle tympanum and middle and inner ear trauma associated with shock waves from underwater explosions (Viada et al. 2008).

4.2.1.6 Diving

The behavior of post-hatchlings and juvenile green turtles raised in captivity indicate that turtles in pelagic habitats live and feed at or near the ocean surface, and that their dives do not normally exceed several meters (Hazel et al. 2009; NMFS and USFWS 1998b). Data from Australia indicate green sea turtles rarely dive deep, staying in upper 8 m of the water column (Hazel et al. 2009). Daytime dives were shorter and shallower than those at night (Ballorain et al. 2013; Hazel et al. 2009).

In their coastal habitat, green turtles typically make dives shallower than 100 feet (30.5 m) (Hatase et al. 2006a; Hays et al. 2000; Hochscheid et al. 2005; Houghton et al. 2002) and often do not exceed 16.8 m (55 feet) (Hays et al. 2000; Rice and Balazs 2008a), although they are known to feed and rest at depths of 19.8 to 50.3 m (65 to 165 ft) (Balazs 1980; Brill et al. 1995). Green turtles migrating between the northwestern and main Hawaiian Islands reached a maximum depth greater than 135.6 m (445 feet) at night (the deepest dives ever recorded for a green turtle). The mean maximum night dive depth was 35 to 50 m (115 to 164 feet) but only 4.3 m (14.1 feet) during the day (Rice and Balazs 2008b).

Time spent resting and dive duration increased significantly with decreases in seasonal water temperatures. Subadults routinely dive to 20 m for 9 to 23 minutes, with a maximum recorded dive of 66 minutes (Brill et al. 1995; I-Jiunn 2009). Green sea turtles along Taiwan may rest during long, shallow dives (I-Jiunn 2009). Dives by females may be shorter in the period leading up to nesting (I-Jiunn 2009).

4.2.1.7 Natural threats

Natural threats include predation, environmental factors, and disease. Herons, gulls, dogfish, and sharks prey upon hatchlings. Adults face predation primarily by sharks and to a lesser extent by killer whales. Predators (primarily of eggs and hatchlings) also include dogs, pigs, rats, crabs, sea birds, reef fishes, and groupers (Bell et al. 1994; Witzell 1981). All sea turtles except leatherbacks can undergo “cold stunning” if water temperatures drop below a threshold level, which can be lethal.

Fibropapillomatosis, an epizootic disease producing lobe-shaped tumors on the soft portion of a turtle’s body, has been found to infect green turtles, most commonly juveniles (Williams Jr. et al. 1994). For unknown reasons, the frequency of a disease called fibropapillomatosis is much higher in green sea turtles than in other species and threatens a large number of existing subpopulations. Extremely high incidence has been reported in Hawaii, where affliction rates peaked at 47 to 69 percent in some foraging areas (Murakawa et al. 2000). A to-date unidentified virus may aid in the development of fibropapillomatosis (Work et al. 2009). Green sea turtles with an abundance of barnacles have been found to have a much greater probability of having health issues (Flint et al. 2009). The fungal pathogens *Fusarium falciforme* and *F. keratoplasticum* kill in excess of 90 percent of sea turtle embryos they infect and may constitute a major threat to nesting productivity under some conditions (Sarmiento-Ramırez et al. 2014).

4.2.1.8 Anthropogenic threats

Historically, the main cause of the worldwide decline of the green sea turtle was long-term harvest of eggs and adults on nesting beaches and juveniles and adults on feeding grounds. Green turtles were traditionally prized for their flesh, fat, eggs, and shell, and fisheries in the United States and throughout the Caribbean contributed to the decline of the species. Egg removal and poaching of nesting females continues to be a problem for the greater threatened populations nesting throughout the south Pacific Ocean, Eastern Atlantic Ocean, Indian Ocean and some areas in the Caribbean (as summarized in (Seminoff 2004). Removal of eggs each nesting season can severely impact juvenile cohorts that would have recruited from the post-hatchling phase while poaching of nesting females reduces the abundance of reproductive adults as well as potential for annual egg production. Both these impacts lead to declines in overall survival and reproduction for these respective populations. Despite substantial declines in the population of green sea turtles in these respective regions, intentional harvest remains legal in many countries and remains a threat to populations worldwide.

Green turtles depend on shallow foraging grounds with sufficient benthic vegetation and normal beach temperatures (Ackerman 1997). Structural impacts to nesting habitat include the construction of buildings and pilings, beach armoring and renourishment, and sand extraction (Bouchard et al. 1998; Lutcavage et al. 1997). Direct destruction of foraging areas due to dredging, boat anchorage, deposition of soil, and siltation (Coston-Clements and Hoss 1983; Williams 1988) may have considerable effects on the distribution of foraging green turtles. These factors may directly, through loss of beach habitat, or indirectly, through changing thermal profiles and increasing erosion, serve to decrease the amount of nesting area available to nesting females, and may evoke a change in the natural behaviors of adults and hatchlings (Ackerman 1997; Witherington et al. 2003; Witherington et al. 2007). Eutrophication, heavy metals, radioactive elements, and hydrocarbons all may reduce the extent, quality, and productivity of foraging grounds (Frazier 1980; McKenzie et al. 1999; Storelli and Marcotrigiano 2003).

On the Pacific coast of Mexico in the mid-1970s, more than 70,000 green turtle eggs were harvested every night. Hundreds of mostly immature green sea turtles were killed between 2006 and 2008 due to bycatch and direct harvest along Baja California Sur (Senko et al. 2014). Very few green sea turtles are caught via bycatch in U.S. fisheries (Finkbeiner et al. 2011). However, a legal fishery operates in Madagascar that harvested about 10,000 green turtles annually in the mid-1990s. Green sea turtles are killed because they are seen as competitors for fishery resources in parts of India (Arthur et al. 2013). Between 1991 and 2011, an average of 8,169 green sea turtles were harvested annually along the Caribbean coast of Nicaragua (over 171,000 over this period); this rate that has been in decline potentially due to population depletion (Lagueux et al. 2014).

The presence of lights on or adjacent to nesting beaches alters the behavior of nesting adults (Witherington 1992) and is often fatal to emerging hatchlings as they are attracted to light sources and drawn away from the water (Witherington and Bjorndal 1991).

Pollution also threatens the pelagic habitat of young green turtles. The pelagic drift lines that young green turtles inhabit tend to collect floating debris such as plastics, oil, and tar (Carr 1987; Moore et al. 2001). Ingestion of plastic and other marine debris is another source of morbidity and mortality (Stamper et al. 2009). Green sea turtles stranded in Brazil were all found to have ingested plastics or fishing debris (n = 34), although mortality appears to have resulted in three cases (Tourinho et al. 2009). Contact with oil and the ingestion of plastics and tar are known to kill sea turtles (Carr 1987; Lutcavage et al. 1995). Older juvenile green turtles have been found dead after ingesting seaborne plastics (Balazs 1985; Bjorndal et al. 1994b). Further, the introduction of alien algae species threatens the stability of some coastal ecosystems and may lead to the elimination of preferred dietary species of green sea turtles (De Weede 1996).

Sea level rise may have significant impacts upon green turtle nesting on Pacific atolls. These low-lying, isolated locations could be inundated by rising water levels associated with global warming, eliminating nesting habitat (Baker et al. 2006; Fuentes et al. 2010a). Fuentes et al. (2010a) predicted that rising temperatures would be a much greater threat in the long term to the hatching success of sea turtle turtles in general and green sea turtles along northeastern Australia particularly. Green sea turtles emerging from nests at cooler temperatures likely absorb more yolk that is converted to body tissue than do hatchlings from warmer nests (Ischer et al. 2009). Predicted temperature rises may approach or exceed the upper thermal tolerance limit of sea turtle incubation, causing widespread failure of nests (Fuentes et al. 2010a). Although the timing of loggerhead nesting depends upon sea-surface temperature, green sea turtles do not appear to be affected (Pike 2009).

4.2.1.9 Status and trends

The principal nesting site for green turtles in the Central North Pacific DPS is French Frigate Shoals, where 96 percent of the population (3,710 of 3,846 nesting females) currently nests (Balazs 1980; Lipman and Balazs 1983). Current nesting by green turtles occurs in low numbers (3 to 36 nesting females at any one site) throughout the northwest Hawaiian Islands at Laysan, Lisianski, Pearl and Hermes Reef, and very uncommonly at Midway. Since 2000, green turtle nesting on the main Hawaiian Islands has been identified in low numbers (1 to 24) on seven islands (Frey et al. 2013; Kittinger et al. 2013). Green turtles in the Central North Pacific DPS bask on beaches throughout the northwest Hawaiian Islands and in the main Hawaiian Islands.

Since nesting surveys were initiated in 1973, there has been a marked increase in annual green turtle nesting at East Island, French Frigate Shoals, where approximately 50 percent of the nesting on French Frigate Shoals occurs (Balazs and Chaloupka 2006a; Balazs and Chaloupka 2004). During the first 5 years of monitoring (1973 to 1977), the mean annual nesting abundance was 83 females, and during the most recent 5 years of monitoring (2009 to 2012), the mean annual nesting abundance was 464 females (Balazs and Chaloupka 2006a). This increase over the last 40 years corresponds to an annual increase of 4.8 percent.

Information on in-water abundance trends is consistent with the increase in nesting (Balazs 2000; Balazs et al. 1996; Balazs et al. 2005). The number of immature green turtles residing in foraging areas of the eight main Hawaiian Islands has increased (Balazs et al. 1996). In addition, although the causes are not totally clear, there has been a dramatic increase in the number of basking turtles in the Hawaiian Islands over the last two decades, both in the southern foraging areas of the main islands (Balazs et al. 1996) as well as at northern foraging areas at Midway Atoll (Balazs et al. 2005).

With regard to diversity and resilience, because nesting in the Central North Pacific DPS is unusually concentrated at one site, there is little diversity in nesting areas. Balazs (1980) reported that the distribution of green turtles in the Hawaiian Archipelago has been reduced within historical times, and Kittinger et al. (2013) suggest that a significant constriction in the spatial distribution of important reproduction sites presents a challenge to the population's future and makes this DPS highly vulnerable. Further, the primary nesting site, the French Frigate Shoals, is a low-lying coral atoll that is susceptible to erosion, geomorphological changes and sea level rise, and has already lost significant nesting area (Baker et al. 2006).

5 ENVIRONMENTAL BASELINE

By regulation, environmental baselines for biological opinions include the past and present impacts of all state, Federal, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of State or private actions which are contemporaneous with the consultation in process (50 CFR § 402.02). The environmental baseline for this opinion includes the effects of several activities that affect the survival and recovery of green sea turtles in the action area.

5.1 Climate Change

The latest Assessment Synthesis Report from the Working Groups on the Intergovernmental Panel on Climate Change (IPCC) concluded climate change is unequivocal (IPCC 2014). The Report concludes oceans have warmed, with ocean warming the greatest near the surface (e.g., the upper 75 m have warmed by 0.11^{o}C per decade over the period 1971 to 2010) (IPCC 2014). Global mean sea level rose by 0.19 m between 1901 and 2010, and the rate of sea-level rise since the mid-19th century has been greater than the mean rate during the previous two millennia (IPCC 2014). Additional consequences of climate change include increased ocean stratification, decreased sea-ice extent, altered patterns of ocean circulation, and decreased ocean oxygen levels (Doney et al. 2012). Further, ocean acidity has increased by 26 percent since the beginning of the industrial era (IPCC 2014), and this rise has been linked to climate change. Climate change is also expected to increase the frequency of extreme weather and climate events including, but not limited to, cyclones, heat waves, and droughts (IPCC 2014). Climate change has the potential to impact species abundance, geographic distribution, migration patterns, timing of seasonal activities (IPCC 2014), and species viability into the future. Although it is challenging to predict the precise consequences of climate change on highly mobile marine species (Simmonds and Isaac 2007), such as many of those considered in this opinion, recent research has identified a range of consequences already occurring.

Marine species ranges are expected to shift as they align their distributions to match their physiological tolerances under changing environmental conditions (Doney et al. 2012). Hazen et al. (2012) examined distribution and diversity of top predators in the Pacific Ocean in light of rising sea surface temperatures using a database of electronic tags and output from a global climate model. He predicted up to a 35 percent change in core habitat area for some key marine predators in the Pacific Ocean, with some species predicted to experience gains in available core habitat and some predicted to experience losses. Notably, leatherback sea turtles were predicted to gain core habitat area, whereas loggerhead sea turtles and blue whales were predicted to experience losses in available core habitat. McMahon and Hays (2006) predicted increased ocean temperatures would expand the distribution of leatherback sea turtles into more northern latitudes.

The final rule to list 11 DPSs of green sea turtles under the Endangered Species Act (81 FR 20057) listed climate change as a threat for green sea turtles from the Central North Pacific DPS. For example, in some locations, rising sea levels are projected to inundate some sea turtle nesting beaches (Caut et al. 2009; Wilkinson and Souter 2008), change patterns of coastal erosion and sand accretion that are necessary to maintain those beaches, and increase the number of turtle nests destroyed by tropical storms and hurricanes (Wilkinson and Souter 2008). The loss of nesting beaches may have catastrophic effects on sea turtle populations if they are unable to colonize new beaches, or if new beaches do not provide the habitat attributes (e.g., sand depth, temperature regimes, and refuge) necessary for egg survival. As stated in the proposed rule (80 FR 15271), it remains unclear how nesting habitat loss will impact future nesting in the Hawaiian Islands. Additionally, increasing temperatures in sea turtle nests, as is expected with climate change, alters sex ratios, reduces incubation times (producing smaller hatchlings), and reduces nesting success due to exceeded thermal tolerances (Fuentes et al. 2009a; Fuentes et al. 2010b; Fuentes et al. 2009b; Glen et al. 2003). Changes in global temperatures could also affect juvenile and adult distribution patterns. Possible changes to ocean currents and dynamics may result in negative effects to natural dispersal during a complex life cycle (Houtan and Halley 2011), and possible nest mortality linked to erosion may result from increased storm frequency (Van Houtan and Bass 2007) and intensity (Keller et al. 2009). All of these temperature related impacts have the potential to significantly impact sea turtle reproductive success and ultimately, long-term species viability.

Poloczanska et al. (2009) noted that extant marine turtle species have survived past climatic shifts, including glacial periods and warm events, and therefore, may have the ability to adapt to ongoing climate change (e.g., by finding new nesting beaches). However, the authors also suggested since the current rate of warming is very rapid, expected changes may outpace sea turtles' ability to adapt. Hawkes et al. (2009) stated that if turtles cannot adapt quickly, they may face local to widespread extirpations (cited in 80 FR 15271).

5.2 Vessel Interactions

Vessel interactions were identified as a threat to sea turtles around the Hawaiian Islands in the final rule to list 11 DPSs of green sea turtles under the Endangered Species Act (81 FR 20057). Vessel strike of sea turtles is poorly studied, but has the potential to be highly significant (Work et al. 2010). Sea turtles must surface to breath and several species are known to bask at the surface for long periods. Research found that sea turtles likely cannot move out of the way of vessels moving at more than 4 km/hr; most vessels move far faster than this in open water (Hazel et al. 2007; Work et al. 2010). Chaloupka et al. (2008c) report that of the 3,745 green turtle strandings in the Hawaiian Archipelago from 1982 to 2003, 2.5 percent were caused by boat strike. However, it should be noted that not all struck sea turtles are likely to strand (NMFS 2008). Based on an observed annual average of 8 green sea turtles stranded in the Main Hawaiian Islands between 1982 and 2007 (as compiled from the Hawaii Sea Turtle Stranding Database), and after applying a correction factor for those that do not strand, NMFS estimates 25 to 50 green sea turtles are killed by vessel strike annually in the Main Hawaiian Islands (NMFS 2008). The majority of strandings are likely the result of strikes with relatively small, but high-speed fishing boats making thousands of trips through Hawaiian nearshore waters annually. The frequency of vessel strike in open ocean waters surrounding Hawaii is much less clear. It is assumed that if an animal is struck in waters further from shore, it is less likely to strand and be documented.

5.3 Ambient and Anthropogenic Noise

Noise in the ocean is the result of both natural and anthropogenic sources. Natural sources of noise include processes such as earthquakes, wind-driven waves, rainfall, bio-acoustic sound generation, and thermal agitation of the seawater. Anthropogenic noise is generated by a variety of activities including shipping, oil and gas exploration, development, military operations (e.g., sonars and explosions), fishing (e.g., commercial/civilian sonars, acoustic deterrent, and harassment devices), research (e.g., air-guns, sonars, telemetry, communication, and navigation), construction, and recreational boating. Sources of anthropogenic noise in some areas of the world are becoming more pervasive, leading to increased oceanic background noise levels at some frequencies as well as peak sound intensity levels. Many anthropogenic sources of noise are located along shipping routes and encompass coastal and continental shelf waters, which are areas that are important marine habitats.

The scientific community recognizes the addition of anthropogenic sound to the marine environment as a stressor that could possibly harm marine animals or significantly interfere with their normal activities (NRC 2005). Once detected, some sounds may produce a behavioral response, including but not limited to, changes in habitat to avoid areas of higher noise levels, changes in diving behavior, or changes in vocalization (MMC 2007). Little is known about how sea turtles use sound in their environment. Based on knowledge of their sensory (Bartol and Ketten 2006; Moein Bartol and Musick 2003), sea turtles may be able to detect objects within the water column (e.g., vessels, prey, predators) via some combination of auditory and visual cues. However, research examining the ability of sea turtles to avoid collisions with vessels shows they may rely more on their vision than auditory cues (Hazel et al. 2007). Similarly, while sea turtles may rely on acoustic cues to identify nesting beaches, they appear to rely on other non-acoustic cues for navigation, such as magnetic fields (Lohmann and Lohmann 1996a; Lohmann and Lohmann 1996b) and light (Avens and Lohmann 2003). Additionally, they are not known to produce sounds underwater for communication.

5.3.1 Shipping and vessel traffic

Much of the increase in noise in the ocean environment is due to increased shipping as ships become more numerous and of larger tonnage (Hildebrand 2009; McKenna et al. 2012; NRC 2003). Shipping constitutes a major source of low-frequency noise in the ocean, particularly in the Northern Hemisphere where the majority of ship traffic occurs. At frequencies below 300 Hz, ambient noise levels are elevated by 15 to 20 dB when exposed to sounds from ships at a distance (McKenna et al. 2013). Analysis of noise from ships revealed that their propulsion systems are a dominant source of radiated underwater noise at frequencies less than200 Hz (Ross 1976). Additional sources of ship noise include rotational and reciprocating machinery that produces tones and pulses at a constant rate. Individual vessels produce unique acoustic signatures that may change with ship speed, vessel load, and activities that may be taking place on the vessel. Peak spectral levels for individual commercial ships are in the frequency band of 10 Hz to 50 Hz and range from 195 dB re $\mu Pa^2/Hz$ at 1 m for fast-moving (greater than 20 knots) supertankers to 140 dB re $\mu Pa^2/Hz$ at 1 m for small fishing vessels (NRC 2003). Small boats with outboard or inboard engines produce sound that is generally highest in the mid-frequency (1 kHz to 5 kHz) range and at moderate (150 to 180 dB re 1 µPa at 1 m) source levels (Erbe 2002; Gabriele et al. 2003; Kipple and Gabriele 2004). On average, noise levels are higher for the larger vessels and increased vessel speeds resulted in higher noise levels.

Ocean shipping is a significant component of Hawaii’s economy. Several shipping ports exist in Hawaii, including Nawailiwili on the southeast coast of Kauai (outside of the action area). Data from the U.S. Army Corps of Engineers U.S. Waterway Network indicate that major shipping routes around Hawaii are generally outside of the action area (Figure 5), though military and non-military vessels (e.g., recreational, tourist, fishing) do occur in the PMRF.

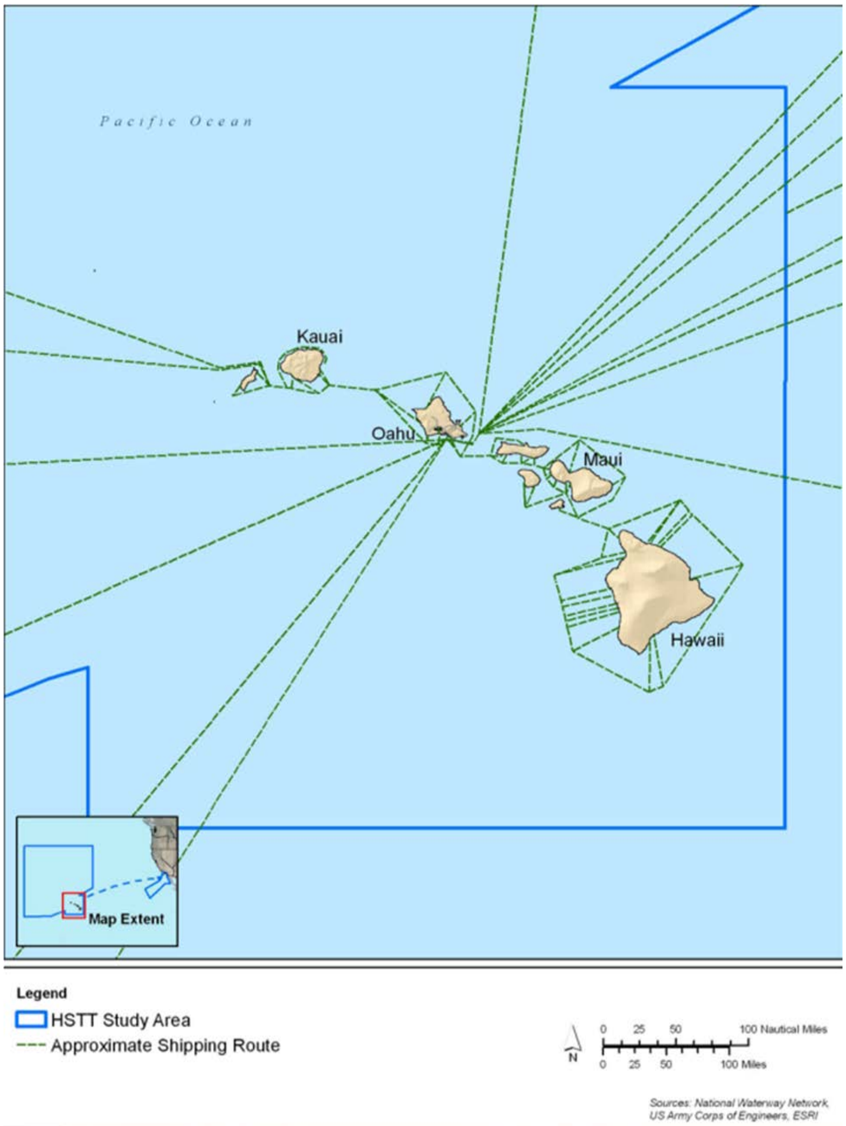


Figure 5. Approximate shipping routes around the Main Hawaiian Islands. Source: Navy (2013).

5.3.2 Ongoing military activities

The U.S. Navy conducts military readiness activities in the HRC, which includes the action area (i.e., PMRF). The PMRF supports military training operations from small, single-unit exercises up to largescale, multiple-unit battle group scenarios using a variety of aircraft, surface combatant vessels and submarines. These activities are a source of anthropogenic noise in the action area. Specific activities that occur in the PMRF include, but are not limited to, anti-submarine warfare and missile testing. Potential noise-related stressors associated with these activities include vessel and aircraft noise, sonar, and noise from explosive ordnance detonations. A more comprehensive description of these activities is in the Hawaii-Southern California Training and Testing Environmental Impact Statement/Overseas Environmental Impact Statement (Navy 2013). NMFS issued a biological opinion on the effects of these activities in April 2015. The effects analysis in the opinion estimated three green sea turtles would die annually as a result of Navy acoustic stressors in the HRC. Additionally, the effects analysis in the opinion estimated that there would be 7,273 instances of behavioral harassment, 405 instances of temporary threshold shift, 26 instances of permanent threshold shift, and 17 instances of slight lung injury to Pacific sea turtles[1] in the HRC on an annual basis from the acoustic effects of Navy military readiness activities. The majority of Pacific sea turtles in the Hawaii Range Complex were expected to be green turtles. The opinion concluded that the Navy's military readiness activities were likely to adversely affect, but would not jeopardize the survival or recovery of green sea turtles.

5.4 Fisheries Interactions

Sea turtles may be impacted by fisheries through entrapment or entanglement in actively fished gear, or may be impacted through entanglement in derelict fishing gear. Incidental capture in fisheries was identified in the proposed rule to list 11 DPSs of green sea turtles under the Endangered Species Act as a significant threat to sea turtles of the Central North Pacific DPS (80 FR 15271). Assessing the impact of fisheries on such species is difficult, due to the large number of fisheries that may interact with the animals, and the inadequate protected species monitoring that occurs in many of those fisheries.

A large number of sea turtles are killed or injured in fisheries worldwide each year (e.g., (Finkbeiner et al. 2011)). The primary fisheries that are known to affect the Central North Pacific DPS of green sea turtles are commercial longline and gillnet as well as other hook and line fisheries (primarily recreational). U.S. longline fisheries are required to use circle hooks, dehookers, line clippers, and crewmember training in order to minimize impacts to sea turtles. These measures have reduced green sea turtle interactions to negligible levels (80 FR 15271). Foreign longline vessels do not have the same requirements and it is estimated that 100 green sea turtles from the Central North Pacific DPS are captured and killed each year by these vessels (NMFS 2012) 80 FR 15271). Gillnet fisheries in the Main Hawaiian Islands have documented instances where green sea turtles are incidentally entangled in net gear, sometimes resulting in mortality (80 FR 15271; (Francke 2013). Hook and line fishing from shore and boats in the Hawaiian Islands also hooks and entangles sea turtles (Francke 2013; NMFS 2012) 80 FR 15271), though the chance of survival is higher than if caught in a gillnet (Chaloupka et al. 2008b).

[1] Sea turtle species-specific density estimates were not available for the Hawaii Range Complex, so all Pacific sea turtles in the HSTT opinion were combined into one generic sea turtle group.

5.5 Marine Debris

Anthropogenic marine debris is prevalent throughout the action area, originating from a variety of oceanic and land-based sources. The final rule to list 11 DPSs of green sea turtles under the Endangered Species Act (81 FR 20057) listed marine debris as a threat to green sea turtles in the Hawaiian Islands and throughout their range.

Debris can be introduced into the marine environment by its improper disposal, accidental loss, or natural disasters (Watters et al. 2010), and can include plastics, glass, derelict fishing gear, derelict vessels, or military expendable materials. Though debris abundance is well understood in shallow-water, shoreline, and surface-water habitats, debris can also settle into deep water benthic habitats (Watters et al. 2010). Marine debris affects marine habitats and marine life worldwide, primarily by entangling or choking individuals that encounter it. Despite debris removal and outreach to heighten public awareness, marine debris in the environment has not been reduced (Academies 2008). Stranding information shows that entanglement in lost or discarded fishing line is one of the causes of green turtle strandings and mortality in the main Hawaiian Islands (81 FR 20057).

Anthropogenic marine debris can also be accidentally consumed while foraging. Recently weaned juveniles, who are investigating multiple types of prey items, may be particularly vulnerable to ingesting non-food items (Baird and Hooker 2000; Schuyler et al. 2013). This can have significant implications for an animal’s survival, potentially leading to starvation, malnutrition, or internal injuries from consumption. Parker et al. (2005) conducted a diet analysis of 52 loggerhead sea turtles collected as bycatch from 1990 to 1992 in the high seas drift gillnet fishery in the central north Pacific. The authors found that 34.6 percent of the individuals sampled had anthropogenic debris in their stomachs (e.g., plastic, Styrofoam, paper, rubber, etc.). Similarly, a study of green sea turtles found that 61 percent of those observed stranded had ingested some form of marine debris, including rope or string, which may have originated from fishing gear (Bugoni et al. 2001).

5.6 Disease

Fibropapillomatosis is the most significant cause of stranding and mortality in green turtles in Hawaii, accounting for 28 percent of standings’ with an 88 percent mortality rate of afflicted stranded turtles (Chaloupka et al. 2008c). While the disease appears to have regressed over time (Chaloupka et al. 2009), it persists in the population at levels of spatial variability (Van Houtan et al. 2010). Van Houtan et al. (2010) also suggest a potential relationship exists between the expression of FP and the State’s land use, waste-water management practices, and invasive macroalgae.

5.7 Scientific Research

Scientific research permits issued by NMFS currently authorize studies on green sea turtles on and around Hawaii, some of which extend into portions of the action area. Currently, there are 866 authorized annual non-lethal takes of green sea turtles that could occur on or around Hawaii. The issuance of these research permits was considered in section 7 consultations by NMFS.

Authorized research on ESA-listed sea turtles includes capture, handling, restraint, tagging, biopsy, blood sampling, lavage, ultrasound, and tetracycline injection.

5.8 Conclusion on the Impact of the Environmental Baseline

Collectively, the stressors described above have had, and likely continue to have, lasting impacts on green sea turtles in the action area. These stressors include, but are not limited to, climate change, vessel interactions, fisheries, marine debris, scientific research, and military readiness activities. These factors are ongoing and are expected to occur contemporaneously with the proposed action. Assessing the aggregate impacts of these stressors on green sea turtles is difficult and, to our knowledge, no such analysis exists. This becomes even more difficult considering that green turtles are wide ranging and subject to stressors in locations well beyond the action area. We consider the best indicator of the aggregate impact of the *Environmental Baseline* on green sea turtles in the action area to be the status of this species. As described in the *Status of Listed Resources* section of this opinion, the Central North Pacific DPS of green sea turtles is generally experiencing increases in nesting and in-water abundance. This indicates that the species is likely increasing in abundance despite the potential negative impacts of the factors described in the *Environmental Baseline* section.

6 Effects of the Action on ESA-Listed Species and Critical Habitat

Section 7 regulations define “effects of the action” as the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline (50 CFR 402.02). Indirect effects are those that are caused by the proposed action and are later in time, but are reasonably certain to occur. This effects analyses section is organized following the stressor, exposure, response, risk assessment framework.

As was stated in Section 3, this opinion includes both a jeopardy analysis and an adverse modification analysis.

The jeopardy analysis relies upon the regulatory definition of “to jeopardize the continued existence of a listed species,” which is “to engage in an action that would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species” (50 CFR 402.02). Therefore, the jeopardy analysis considers both survival and recovery of the species.

6.1 Stressors Associated with the Proposed Action

The potential stressors (risks) to ESA-listed species that we analyzed based on the activities that the Air Force proposes to conduct in the PMRF action area are summarized in Table 4.

Table 4. Air Force stressor categories and description of the stressors analyzed in this opinion.

Stressor	Description of Stressor
Acoustic (launch and detonation noise from explosives, aircraft noise)	Effects on species from acoustic sources (e.g., explosives) are dependent on a number of factors, including the proximity of the animal to the sound source, and the duration, frequency, and intensity of the sound. Underwater sound propagation is highly dependent upon environmental characteristics such as bathymetry, bottom type, water depth, temperature, and salinity. The sound received at a particular location will be different than near the source due to the interaction of many factors, including propagation loss; how the sound is reflected, refracted, or scattered; the potential for reverberation; and interference due to multi-path propagation. Explosives used during this mission include bombs and missiles. Detonations would occur near the water's surface over waters deeper than 4,645 m (15,240 ft), and approximately 44 nm from shore. Noise associated with munitions firing and explosives at the surface could occur anywhere within the impact area. Sound could be generated by the launch or dropping of the munitions, the munition flying through the air, the detonation at the surface of the water, or through vibrations from detonations that propagate through the water. Aircraft are used for firing the munitions throughout the action area, contributing airborne sound via motor/propeller noise to the ocean environment. Aircraft sounds have more energy at lower frequencies. Since the aircrafts will be taking off and landing at out bases, most sound from the aircraft would be during pre and post-mission surveys and refueling in the action area should a fighter jet need fuel.
Physical disturbance and strike (military expended materials)	Physical disturbances, including direct strikes on ESA-listed animals, may occur in association with munitions deployment and materials expended from detonations at the water surface. Military expended materials include all pieces and fragments from explosive munitions, which have the potential to contribute to the physical disturbance and strike stressor either in-air or in-water or both.
Ingestion of munition fragments	Marine mammals or sea turtles could ingest fragments of exploded bombs and missiles. Fragments would result from fractures in the munitions casing and would vary in size depending on the size of the net explosive weight and munition type. These solid metal materials would quickly sink through the water column and settle to the seafloor.

Secondary (explosion byproducts, metals, and chemicals)	Secondary stressors associated with explosive ordnance activities could pose indirect impacts to ESA-listed marine species through habitat degradation or alteration or an effect on prey availability. Effects to habitat and prey availability may result from: (1) explosives, (2) explosion byproducts and unexploded ordnance, (3) metals, and (4) chemicals. In addition to directly impacting marine species, explosions could impact other species in the food web, including prey species that ESA-listed marine species feed upon. The impacts of explosions would differ depending upon the type of prey species in the detonation area. Explosion byproducts are not toxic to marine organisms at realistic exposure levels (Rosen and Lotufo 2010). Relatively low solubility of most explosives and their degradation products means that concentrations of these contaminants in the marine environment are relatively low and readily diluted. Metals are introduced into seawater and sediments as a result of explosive ordnance activities. Missiles may also release potentially harmful chemicals into the marine environment, though properly functioning missiles combust most of their propellants, leaving benign or readily diluted soluble combustion byproducts (e.g., hydrogen cyanide). Operational failures allow propellants and their degradation products to be released into the marine environment. The greatest risk to marine species would be from perchlorate released from missiles that operationally fail. Perchlorate is highly soluble in water, persistent, and impacts metabolic processes in many plants and animals.

6.1.1 Summary of Effect Determinations by Stressor

Table 5 below summarizes our final effects determinations by stressor category.

Table 5. Stressors associated with the Long Range Strike Weapon Systems Evaluation Program activities for 2016 in the PMRF area and the effects determination for ESA-listed species. The species in bold are those that are likely to be adversely affected by the Air Force's Long Range Strike Weapon Systems Evaluation Program activities.

Common Name	Overall ESA Determination	Effect Determinations by Stressor						
		Acoustic			Physical		Ingestion	Secondary
		Detonation Noise	Launch Noise	Aircraft Noise	Military expended materials	Munition strike	Munitions	Explosion byproducts, metals, chemicals, and food web effects
Blue whale	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Fin whale	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Sei whale	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Sperm whale	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA

False killer whale (Main Hawaiian Islands Insular DPS)	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Hawaiian monk seal	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Green sea turtle (Central North Pacific DPS)	**LAA**	**LAA**	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Green sea turtle (East Indian-West Pacific, Central West Pacific, Southwest Pacific, Central South Pacific, Southwest Pacific, Central South Pacific, and East Pacific DPSs)	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Loggerhead sea turtle (North Pacific Ocean DPS)	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Hawksbill sea turtle	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Olive ridley sea turtle	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Leatherback sea turtle	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA

6.2 Stressors Not Likely to Adversely Affect ESA-listed Species

The following section discusses stressors that are not likely to adversely affect ESA-listed species. If a stressor is likely to adversely affect any of the ESA-listed species in the action area, it is carried forward in our effects analysis.

6.2.1 Effects of Aircraft Noise

Many of the activities the Air Force conducts in the action area involve some level of activity from aircraft that include helicopters, bombers, and fighter jets. Low-flying aircraft produce sounds that marine mammals and sea turtles can hear when they occur at or near the ocean's surface. Underwater sounds from aircraft are strongest just below the surface and directly under the aircraft. Sounds from aircraft would not have physical effects on marine mammals or sea turtles, but represent acoustic stimuli (primarily low-frequency sounds from engines and rotors) that have been reported to affect the behavior of some marine mammals and sea turtles. It should also be noted that the air-sea interface constitutes a substantial sound barrier, with sound waves in the water being reduced by a factor of more than a thousand when they cross this boundary (Hildebrand 2005).

We did not estimate the number of ESA-listed marine mammals or sea turtles that are likely to be exposed to noise from aircraft overflight or other fixed or rotary-wing aircraft operations at altitudes low enough for the sounds to be prominent at, or immediately below, the ocean's surface. We assume any ESA-listed species that occur in the action area during activities that involve aircraft are likely to be exposed to minor acoustic stimuli associated with aircraft traffic.

Studies have shown that aircraft presence and operation can result in changes in behavior of cetaceans (Arcangeli and Crosti 2009; Holt et al. 2009; Luksenburg and Parsons 2009b; Noren et al. 2009; Patenaude et al. 2002; Richter et al. 2006; Richter et al. 2003b; Smultea et al. 2008). In a review of aircraft noise effects on marine mammals, Luksenburg and Parsons (2009a) determined that the sensitivity of whales and dolphins to aircraft noise may depend on the animals' behavioral state at the time of exposure (e.g. resting, socializing, foraging or travelling) as well as the altitude and lateral distance of the aircraft to the animals. While resting animals seemed to be disturbed the most, low flying aircraft with close lateral distances over shallow water elicited stronger disturbance responses than higher flying aircraft with greater lateral distances over deeper water (Patenaude et al. 2002; Smultea et al. 2008) in Luksenburg and Parsons (2009a)).

Thorough reviews on the behavioral reactions of marine mammals to aircraft and missile overflight are presented in Richardson et al. (1995), Efroymson et al. (2000), Luksenburg and Parsons (2009b), and Holst et al. (2011). The most common responses of cetaceans to aircraft overflights were short surfacing durations, abrupt dives, and percussive behavior (breaching and tail slapping) (Nowacek et al. 2007). Other behavioral responses such as flushing and fleeing the area of the source of the noise have also been observed (Holst et al. 2011; Manci et al. 1988). Richardson et al. (1995) noted that marine mammal reactions to aircraft overflight largely consisted of opportunistic and anecdotal observations. These observations lack a clear distinction between reactions potentially caused by the noise of the aircraft and the visual cue an aircraft presents. In addition, it was suggested that variations in the responses noted were due to other undocumented factors associated with overflight (Richardson et al. 1995). These factors could include aircraft type (single engine, multi-engine, jet turbine), flight path (centered on the animal, off to one side, circling, level and slow), environmental factors such as wind speed, sea state, cloud cover, and locations where native subsistence hunting continues.

Mysticetes either ignore or occasionally dive in response to aircraft overflights (Efroymson et al. 2000; Koski et al. 1998). Richardson et al. (1995) reported that while data on the reactions of mysticetes is meager and largely anecdotal, there is no evidence that single or occasional aircraft flying above mysticetes causes long-term displacement of these mammals. In general, overflights above 305 m (1,000 ft) do not cause a reaction.

Bowhead whales in the Beaufort Sea exhibited a transient behavioral response to fixed-wing aircraft and vessels. Reactions were frequently observed at less than 305 m (1,000 ft) above sea level, infrequently observed at 457 m (1,500 ft), and not observed at 610 m (2,000 ft) above sea level (Richardson et al. 1995). Bowhead whales reacted to helicopter overflights by diving, breaching, changing direction or behavior, and altering breathing patterns. Behavioral reactions decreased in frequency as the altitude of the helicopter increased to 150 m (492 ft) or higher. It should be noted that bowhead whales may have more acute responses to anthropogenic activity than many other marine mammals since these animals are often presented with limited egress due to limited open water between ice floes. Additionally, many of these animals may be hunted by Alaska Natives, which could lead to animals developing additional sensitivity to human noise and presence.

Variable responses to aircraft have been observed in toothed whales, though overall little change in behavior has been observed during flyovers. Toothed whale responses to aircrafts include diving, slapping the water with their flukes or flippers, swimming away from the direction of the aircraft, or not visibly reacting (Richardson et al. 1995). Several authors have reported that sperm whales did not react to fixed-wing aircraft or helicopters in some circumstances (Au and Perryman 1982; Clarke 1956; Gambell 1968; Green et al. 1992a) and reacted in others (Clarke 1956; Fritts et al. 1983; Mullin et al. 1991; Patenaude et al. 2002; Richter et al. 2006; Richter et al. 2003a; Smultea et al. 2008; Wursig et al. 1998). Smultea et al. (2008) studied the response of sperm whales to low-altitude (233 to 269 m) flights by a small fixed-wing airplane near Kauai and reviewed data available from other studies. They concluded that sperm whales responded behaviorally to aircraft passes in about 12 percent of encounters. All of the reactions consisted of sudden dives and occurred when the aircraft was less than 360 m from the whales (lateral distance). They concluded that the sperm whales had perceived the aircraft as a predatory stimulus and responded with defensive behavior. In at least one case, Smultea et al. (2008) reported that the sperm whales formed a semi-circular “fan” formation that was similar to defensive formations reported by other investigators.

Other authors have corroborated the variability in sperm whales’ reactions to fixed-wing aircraft or helicopters (Green et al. 1992b; Richter et al. 2006; Richter et al. 2003b; Smultea et al. 2008; Wursig et al. 1998). In one study, sperm whales showed no reaction to a helicopter until they encountered the downdrafts from the rotors (Richardson et al. 1995). A group of sperm whales responded to a circling aircraft (altitude of 244 to 335 m [800 to 1,100 ft]) by moving closer together and forming a defensive fan-shaped semicircle, with their heads facing outward. Several individuals in the group turned on their sides, apparently to look up toward the aircraft (Smultea et al. 2008). Whale-watching aircraft apparently caused sperm whales to turn more sharply but did not affect blow interval, surface time, time to first click, or the frequency of aerial behavior (Richter et al. 2003b). Air Force aircraft do not fly at low altitude, hover over, or follow whales and so are not expected to evoke this type of response.

Smaller delphinids generally react to overflights either neutrally or with a startle response (Wursig et al. 1998). The same species that show strong avoidance behavior to vessel traffic (*Kogia* species and beaked whales) also react to aircraft (Wursig et al. 1998). Beluga whales reacted to helicopter overflights by diving, breaching, changing direction or behavior, and altering breathing patterns to a greater extent than mysticetes in the same area (Patenaude et al. 2002). These reactions increased in frequency as the altitude of the helicopter dropped below 150 m (492 ft).

Based on sea turtle sensory biology (Bartol et al. 1999b; Ketten and Bartol 2005; Ketten and Bartol 2006; Lenhardt et al. 1994; Ridgway et al. 1969), sound from low flying aircraft could be heard by a sea turtle that is at or near the surface. Turtles might also detect low flying aircraft via visual cues such as the aircraft's shadow. Hazel et al. (2007) suggested that green turtles rely more on visual cues than auditory cues when reacting to approaching water vessels. This suggests that sea turtles might not respond to aircraft overflights based on noise alone.

In conclusion, the low number of aircraft flights (i.e., just pre- and post-survey flights), typical altitudes of flights, sporadic occurrence of flights, limited duration of flights, deep water depths in the action area, and the lack of substantial sound propagation into the water column from aircraft indicate there is a low probability of exposing ESA-listed marine mammals and sea turtles to aircraft noise at perceivable levels. In the event an ESA-listed species was exposed to aircraft noise, it would likely result in temporary behavioral responses. These behavioral responses would not increase the likelihood of injury from significantly disrupting breeding, feeding, or sheltering and would not rise to the level of take. Therefore, the effects of aircraft noise on ESA-listed species are insignificant and not likely to adversely affect them.

6.2.2 Effects of Weapons Launch Noise

Aircraft fired munitions are not expected to have sound waves emanating from the firing source that would be of sufficient intensity to propagate a sound wave into the water that could adversely affect ESA-listed species. This is partially due to the height above the surface of the water that the munition would be released from (i.e., between 3,000 and 18,000 feet), but also due to minimal transmission of sound from air to water (Hildebrand 2005). Further, these activities are of limited duration (i.e., nine explosions in 2016 all occurring on the same day) and the increased noise from each launch event would be brief. This limits the likelihood that ESA-listed species would be exposed to noise from weapons launch. Even if an animal were exposed to noise from a weapons launch, at most we would expect a temporary behavioral response, similar to how an animal may respond to aircraft noise. Due to the short duration and sporadic nature of munition firing, the low likelihood that an ESA-listed animal would be in close enough proximity to detect sound from munition firing above water, and the high likelihood that any ESA-listed animal able to detect noise from weapons firing would only react very briefly, an increase in the likelihood of injury from significant disruption of breeding, feeding, or sheltering for ESA-listed marine mammals or fish is not likely. Therefore, the effects of weapons launch noise on ESA-listed marine mammals and sea turtles are insignificant and not likely to adversely affect them.

6.2.3 Effects of Munitions from Ingestion

The only materials small enough to be ingested by ESA-listed marine mammals and sea turtles are fragments from explosive ordnance. The detonations will occur over deep water (approximately 4,600 m depth) and fragments will likely sink quickly and settle on the seafloor. Given the limited time most items will spend in the water column, it is not reasonably expected these items will be accidentally ingested by ESA-listed species not accustomed to foraging on the sea floor. The ESA-listed species potentially exposed to expended munitions while foraging on the sea floor is limited to sperm whales (monk seals and sea turtles forage on the sea floor, but do not forage on the sea floor in deep-water habitat where the detonations will occur; benthic feeding occurs in relatively more shallow, near-shore areas). Sperm whales are capable of foraging along the sea floor in deep water. However, the relatively low density of both sperm whales and explosive fragments on the sea floor suggests ingestion would be rare. Further, an animal would not likely ingest every fragment it encounters. Animals may attempt to ingest a projectile and then reject it, after realizing it is not a food item. Additionally, ingestion of items does not necessarily result in injury or mortality to the individual if the item does not become embedded in tissue (Wells et al. 2008). It is likely that most ingested material would pass through the digestive tract of the animal. Therefore impacts of fragment ingestion would be limited to the unlikely event where a marine mammal or sea turtle might suffer a negative response from ingesting an item that becomes embedded in tissue or is too large to be passed through the digestive system.

In conclusion, ESA-listed species are so unlikely to ingest expended material as to be discountable, or in the case of sperm whales, any ingested materials are likely to pass through the digestive tract without causing injury or any effects rising to the level of take. Therefore, the effects of ingested expended materials on ESA-listed species are either discountable, or insignificant, and not likely to adversely affect them.

6.2.4 Effects of Secondary Stressors

The use of explosive ordnance could pose indirect impacts to marine mammals or sea turtles through impacts to their habitat or prey.

Underwater explosions may reduce available prey items for ESA-listed species by either directly killing prey or by scaring them from the area. Behavioral avoidance of explosive ordnance by prey species may facilitate behavioral avoidance of additional explosives by ESA-listed species as they follow their food source as it flees. This benefit would remove ESA-listed species from blast locations while not interrupting feeding behavior. Due to the infrequent use of explosives and the limited area where explosives are used, it is not expected their use will have a persistent effect on prey availability or the health of the aquatic food web.

Metals used to construct the bombs and missile used by the Air Force include aluminum, steel, and lead. Aluminum is also present in some explosive materials such as tritonal and AFX-757. Metals would be expected to settle to the seafloor after munitions are detonated. Metal ions would slowly leach into the substrate and the water column, causing elevated concentrations in a small localized area around munition fragments. Some of the metals, such as aluminum, occur naturally in the ocean at varying concentrations and would not necessarily impact the substrate or water column. Other metals, such as lead, could cause toxicity in microbial communities in the substrate (Department of the Air Force 2016). However, such effects would be localized and would not significantly affect the overall habitat quality of sediments in the action area. In addition, metal fragments would corrode, degrade, and become encrusted over time. It is extremely unlikely that marine mammals and sea turtles would be indirectly impacted by metals via the water column or sediment because of the small area that could be affected, dilution of any potentially harmful elements leached into the water column, and the low density of ESA-listed species in the area where metals may occur.

Chemical materials include explosive byproducts. Explosive byproducts would be introduced into the water column through detonation of live munitions. Explosive materials associated with long range strike Long Range Strike Weapon Systems Evaluation Program munitions include tritonal and research department explosive, among others. Tritonal is primarily composed of TNT. RDX is sometimes referred to as cyclotrimethylenetrinitramine. Various byproducts are produced during and immediately after detonation of RDX. During the very brief time that a detonation is in progress, intermediate products may include carbon ions, nitrogen ions, oxygen ions, water, hydrogen cyanide, carbon monoxide, nitrogen gas, nitrous oxide, cyanic acid, and carbon dioxide (Becker 1995). However, reactions quickly occur between the intermediates, and the final products consist mainly of water, carbon monoxide, carbon dioxide, and nitrogen gas, although small amounts of other compounds may be produced as well. Chemicals introduced to the water column would be quickly dispersed by waves, currents, and tidal action and eventually be distributed throughout the surrounding open ocean waters. A portion of the carbon compounds, such as carbon monoxide and carbon dioxide, would likely become integrated into the carbonate system (alkalinity and pH buffering capacity of seawater). Some of the nitrogen and carbon compounds, including petroleum products, would be metabolized or assimilated during protein synthesis by phytoplankton and bacteria. Most of the gas products that do not react with the water or become assimilated by organisms would be released to the atmosphere. Due to dilution, mixing, and transformation, none of these chemicals are expected to have significant impacts on ESA-listed species or the marine environment.

Explosive material that is not consumed in a detonation could sink to the substrate and bind to sediments. However, the quantity of such materials is expected to be inconsequential. When munitions function properly, nearly full combustion of the explosive materials occurs, and only extremely small amounts of raw material remain. Additionally, TNT decomposes when exposed to sunlight/ultraviolet radiation and is also degraded by microbial activity (Becker 1995). Several types of microorganisms have been shown to metabolize TNT. Similarly, RDX is decomposed by hydrolysis, ultraviolet radiation exposure, and biodegradation (Department of the Air Force 2016).

Given the information provided above regarding the potential for explosives and byproducts, metals, and chemicals to indirectly affect marine ESA-listed marine mammal and sea turtle species through habitat and prey availability impacts, the likelihood of ESA-listed species being exposed to toxic levels of explosives, explosive byproducts, metals, other chemicals from Long Range Strike Weapon Systems Evaluation Program activities are so unlikely as to be considered discountable. Therefore, secondary stressors from Long Range Strike Weapon Systems Evaluation Program activities are not likely to adversely affect ESA-listed species.

6.2.5 Potential for Direct Physical Strike

This section evaluates the potential for the explosive ordnances used by the Air Force in 2016 to physically strike an ESA-listed species. The potential for acoustic stressors associated with explosive detonations to affect ESA-listed species is evaluated in Section 6.4.1. A total of nine explosive ordnances (one JASSM and eight SDBs) will be released during the 2016 mission. The velocity of bombs and the missile will decrease quickly after the initial impact with the water, thereby decreasing the risk of direct physical strike to animals swimming in the water column at a depth below a few meters. Therefore, the potential for being struck by a bomb or munition would most likely be limited to marine mammals or sea turtles located at the water surface or in the water column close to the surface. In order to be struck, an animal would have to be at the water surface at the same time and location where the weapon would impact the surface of the water. While this is possible, the low densities (see Section 3.1 of this opinion) and dispersed distribution of marine mammals and sea turtles in the action area, as well as the low number of bombs and missiles used in the proposed action, suggest this is highly unlikely. Pre-mission surveys of the impact area (see section 2.4) would reduce this likelihood even further as a bomb or missile launch would not occur if a marine mammal or sea turtle is observed in proximity to the impact area until the animal has left the area. For these reasons, the likelihood of explosive ordnance physically striking an ESA-listed marine mammal or sea turtle during the 2016 Air Force Long Range Strike Weapon Systems Evaluation Program mission is so unlikely as to be considered discountable.

6.3 Mitigation to Minimize or Avoid Exposure

The Air Force will implement visual aerial surveys within the impact area prior to the release of munitions in order to minimize effects to ESA-listed marine mammals and sea turtles (described in section 2.4). These surveys are routinely implemented in the PMRF prior to similar military readiness exercises being conducted by the United States Navy. To date, there have been no documented instances of protected marine species serious injury or mortality in the PMRF from similar activities when the same range clearance procedures were followed. Personnel conducting these surveys are trained and experienced at conducting aerial marine mammal surveys, which helps to ensure the surveys are as effective as possible. Surveys begin as close to weapon release as possible (usually within one hour), reducing the likelihood that protected species could enter the impact area during the time between the survey and detonation. The surveys span an area of 2 nm from the impact point, encompassing the majority of PTS and TTS impact areas for marine mammals and sea turtles. Lastly, due to the speed and altitude of fixed-wing aircraft during protected species surveys, these aircraft may fly the survey pattern multiple times within a 30 minute time period to help ensure that protected species are not missed in the 2 nm zone. We assume that aerial surveys would be more effective at identifying larger individuals (e.g., large whales) than smaller individuals (e.g., juvenile sea turtles).

6.4 Stressors Likely to Adversely Affect ESA-listed Species

The only stressor we determined was likely to adversely affect ESA-listed species during the Air Force's proposed 2016 mission was acoustic stressors from explosive detonations.

6.4.1 Exposure and Response Analysis

The Air Force's analysis to estimate potential exposure of marine mammals and sea turtles to sounds from detonations is summarized in Section 3.1 and fully described in the Air Force's biological assessment and associated appendices (Department of the Air Force 2016). We verified the methodology and data used by the Air Force for their exposure analysis and accept the modeling conclusions on exposure of marine mammals and sea turtles.

6.4.1.1 Marine mammals

The criteria and thresholds used to estimate potential pressure and acoustic impacts to marine mammals were obtained from Finneran and Jenkins (2012) and include mortality, gastrointenstinal tract injury, slight lung injury, PTS, and behavioral harassment. For activities occurring in 2016, the Air Force's analysis indicated there would be no exposures of ESA-listed marine mammals to acoustic stressors from bombing and missile activities at thresholds that would rise to the level of take under the ESA (i.e., mortality, gastrointestinal tract injury, slight lung injury, PTS, TTS, or behavioral harassment). For all ESA-listed marine mammal species considered in this opinion, exposure calculations from model output resulted in decimal values. The highest unrounded ESA-listed marine mammal exposure was 0.05 instances of TTS for sperm whales. These estimates were rounded to the nearest whole number to obtain exposure estimates for the 2016 mission. Following rounding, zero exposures of marine mammals at thresholds that would rise to the level of take under the ESA were estimated to occur.

6.4.1.2 Sea turtles

The criteria and thresholds used to estimate potential pressure and acoustic impacts to sea turtles were also obtained from Finneran and Jenkins (2012). The criteria and thresholds include onset of mortality, onset of slight lung injury, onset of gastrointestinal tract injury, PTS, TTS, and behavioral harassment. The Air Force's exposure analysis (section 3.1) indicated there would be one exposure to an individual from the Pacific sea turtle guild (which included the five ESA-listed sea turtle species within the action area) that would result in TTS. No other sea turtle exposures were estimated to occur at thresholds that would rise to the level of take under the ESA (i.e., onset of mortality, onset of slight lung injury, onset of gastrointestinal tract injury, PTS, or behavioral harassment).

As further described in Section 3.1, we would expect the majority of sea turtles within the action area to be green sea turtles based on observations by Navy divers and contractors in the HRC, distribution, abundance, and migration patterns of sea turtles, and documented nesting sites in the action area. Furthermore, based on the distribution and abundance of green sea turtle DPSs (81 FR 20057), we anticipate the majority of green sea turtles within the action area to be from the

Central North Pacific DPS. Therefore, we assume that the one instance of TTS from the Pacific sea turtle guild will be of a green sea turtle from the Central North Pacific DPS (the DPS whose nesting range encompasses the Hawaiian Islands).

6.4.2 Risk Analysis

Temporary threshold shift is a hearing loss that recovers to the original hearing threshold over a period of time. An animal may not even be aware of a TTS. It does not become deaf, but requires a louder sound stimulus (relative to the amount of TTS) to detect a sound within the affected frequencies. Temporary threshold shift may last several minutes to several days, depending on the intensity and duration of the sound exposure that induced the threshold shift (including multiple exposures).

Little is known about how sea turtles use sound in their environment. Based on knowledge of their sensory biology (Bartol and Ketten 2006; Moein Bartol and Musick 2003), sea turtles may be able to detect objects within the water column (e.g., vessels, prey, predators) via some combination of auditory and visual cues. However, research examining the ability of sea turtles to avoid collisions with vessels shows they may rely more on their vision than auditory cues (Hazel et al. 2007). Similarly, while sea turtles may rely on acoustic cues to identify nesting beaches, they appear to rely on other non-acoustic cues for navigation, such as magnetic fields (Lohmann and Lohmann 1996a; Lohmann and Lohmann 1996b) and light (Avens and Lohmann 2003). Additionally, they are not known to produce sounds underwater for communication. As a result, we do not expect the single instance of TTS to have fitness consequences for the individual green sea turtle affected. Because we do not anticipate fitness consequences for the individual animal exposed to sound levels that could cause TTS, we do not expect consequences for the population or the species.

6.5 Cumulative Effects

"Cumulative effects" are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR 402.02). Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

During this consultation, NMFS searched for information on future state, tribal, local, or private actions reasonably certain to occur in the action area. We did not find any information about non-Federal actions other than what has already been described in the *Environmental Baseline*, which we expect will continue into the future. Anthropogenic effects include commercial and recreational fishing, Navy training and testing activities, vessel traffic, ocean noise, and pollution. An increase in these activities could result in an increased effect on ESA-listed species; however, the magnitude and significance of any anticipated effects remain unknown at this time.

6.6 Integration and Synthesis

The *Integration and Synthesis* section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the proposed action. In this section, we add the effects of the action (Section 6) to the environmental baseline (Section 5) and the cumulative effects (Section 6.5) to formulate the agency's biological opinion as to whether the proposed action is likely to: (1) reduce appreciably the likelihood of both the survival and recovery of a ESA-listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) reduce the value of designated or proposed critical habitat for the conservation of the species. These assessments are made in full consideration of the status of the species (Section 4).

The following discussion summarizes the probable risks the proposed action poses to threatened and endangered species that are likely to be exposed. The summary then integrates the exposure profiles presented previously with the results of our response analyses for each of the actions considered in this opinion.

The only stressor associated with the proposed action that we determined was likely to adversely affect ESA-listed species was exposure to acoustic stressors from explosive detonations. The Air Force's acoustic exposure analysis indicated there would be one TTS exposure to an individual from the Pacific sea turtle guild, but no additional sea turtle or marine mammal exposures were estimated to occur at thresholds that would rise to the level of take under the ESA. Based on relative abundance information for sea turtles in the action area, we assume that the one instance of TTS from the Pacific sea turtle guild will be of a green sea turtle from the Central North Pacific DPS (the DPS whose nesting range encompasses the Hawaiian Islands).

As described in the *Status of ESA-listed Species* and *Environmental Baseline* sections of this opinion, the primary anthropogenic threats to the survival and recovery of the Central North Pacific DPS of green sea turtles are direct harvest, incidental bycatch in fisheries, destruction and modification of nesting habitat, disease, predation, and climate change. Despite these threats, available information (e.g., nesting surveys) indicates that Central North Pacific DPS green sea turtle abundance is increasing.

Based on our analysis in this opinion, we conclude that effects from the Air Force's operational evaluations of live long-range strike weapons and other munitions conducted off of the western shores of the island of Kauai in October 2016 would not be expected, directly or indirectly, to appreciably reduce the likelihood of the survival or recovery of the Central North Pacific DPS of green sea turtles in the wild by reducing the reproduction or distribution of the species. We do not expect the single instance of TTS to have fitness consequences for the individual green sea turtle affected because sea turtles do not rely on acoustic cues for most important life functions. Because we do not anticipate fitness consequences for the individual animal exposed to sound levels that could cause TTS, we do not expect consequences for the population or the species.

7 CONCLUSION

During the consultation, we reviewed the current status of the Central North Pacific DPS of green sea turtles. We also assessed the *Environmental Baseline* within the action area, the effects of the proposed action, any effects of interrelated and interdependent actions, and cumulative effects.

Our regulations require us to consider, using the best available scientific data, effects of the action that are "likely" and "reasonably certain" to occur rather than effects that are speculative or uncertain. See 50 C.F.R. § 402.02 (defining to "jeopardize the continued existence of" and "effects of the action"). For the reasons set forth above, and taking into consideration the best available scientific evidence documented throughout this opinion, we conclude that the Air Force's activities are likely to adversely affect, but will not appreciably reduce, the ability of the Central North Pacific DPS of green sea turtles to survive and recover in the wild. Therefore, we conclude that these activities are not likely to jeopardize the continued existence of the Central North Pacific DPS of green sea turtles.

8 INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and Federal regulations pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. "Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by regulation to include significant habitat modification or degradation that results in death or injury to ESA-listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Section 7(b)(4) and section 7(o)(2) provide that taking that is incidental to an otherwise lawful agency action is not considered to be prohibited taking under the ESA if that action is performed in compliance with the terms and conditions of this incidental take statement.

8.1 Amount or Extent of Take

Section 7 regulations require NMFS to specify the impact of any incidental take of endangered or threatened species; that is, the amount or extent, of such incidental taking on the species (50 CFR § 402.14(i)(1)(i)). The amount of take represents the number of individuals that are expected to be taken by actions while the extent of take or "the extent of land or marine area that may be affected by an action" may be used if we cannot assign numerical limits for animals that could be incidentally taken during the course of an action (51 FR 19953).

Based on the analysis in the biological opinion, NMFS anticipates that the proposed action would result in one instance of TTS to an individual from the Central North Pacific DPS of green sea turtle.

8.2 Effects of the Take

In this opinion, NMFS determined that the amount or extent of anticipated take, coupled with other effects of the proposed action, is not likely to result in jeopardy to the species or destruction or adverse modification of critical habitat.

8.3 Reasonable and Prudent Measures

The measures described below are nondiscretionary, and must be undertaken by the Air Force so that they become binding conditions for the exemption in section 7(o)(2) to apply. Section 7(b)(4) of the ESA requires that when a proposed agency action is found to be consistent with section 7(a)(2) of the ESA and the proposed action may incidentally take individuals of ESA-listed species, NMFS will issue a statement that specifies the impact of any incidental taking of endangered or threatened species. To minimize such impacts, reasonable and prudent measures, and term and conditions to implement the measures, must be provided. Only incidental take resulting from the agency actions and any specified reasonable and prudent measures and terms and conditions identified in the incidental take statement are exempt from the taking prohibition of section 9(a), pursuant to section 7(o) of the ESA.

"Reasonable and prudent measures" are nondiscretionary measures to minimize the amount or extent of incidental take (50 CFR 402.02). NMFS believes the reasonable and prudent measures described below are necessary and appropriate to minimize the impacts of incidental take on threatened and endangered species:

1. The Air Force shall have measures in place to limit the potential for interactions with ESA-listed species that may rise to the level of take as a result of the proposed actions described in this opinion.
2. The Air Force shall report all observed interactions resulting in take with any ESA-listed species resulting from the proposed action that are observed.

Monitoring

As discussed in Section 6.4 of this opinion, the estimated take of ESA-listed species from acoustic stressors is based on Air Force modeling, which represents the best available means of numerically quantifying take. As the level of impulsive acoustic activities increases, the level of take is likely to increase as well. For non-lethal take from acoustic sources specified above, feasible monitoring techniques for detecting and calculating actual take of sea turtles do not exist. We are not aware of any other feasible or available means of determining when estimated take levels may be exceeded. Therefore, we must rely on Air Force modeling, and the link between explosive use and the level of take, to determine when anticipated take levels have been exceeded. Reinitiation of consultation shall be required if Air Force monitoring detects any unanticipated form of take of ESA-listed species not specified above.

8.4 Terms and Conditions

To be exempt from the prohibitions of section 9 of the ESA, the Air Force must comply with the following terms and conditions, which implement the Reasonable and Prudent Measures described above and outlines the mitigation, monitoring and reporting measures required by the section 7 regulations (50 CFR 402.14(i)). These terms and conditions are non-discretionary. If the Air Force fails to ensure compliance with these terms and conditions and their implementation of the reasonable and prudent measures, the protective coverage of section 7(o)(2) may lapse.

1. The following term and condition implements reasonable and prudent measure 1:
   a. The Air Force must implement all mitigation and monitoring measures as described in the draft Biological Assessment and in Section 2.4 of this opinion.
2. The following terms and conditions implement reasonable and prudent measure 2:
   a. If a dead or injured marine mammal or sea turtle is observed during or following proposed activities, the Air Force shall immediately (within 24 hours of the discovery) contact NMFS and appropriate stranding networks.
   b. Within 120 days following the completion of the proposed action, the Air Force shall submit a report to NMFS containing the following information
      i. Date and time of the Long Range Strike Weapon Systems Evaluation Program mission;
      ii. A complete description of the pre-exercise and post-exercise activities related to mitigating and monitoring the effects of the Long Range Strike Weapon Systems Evaluation Program mission on marine mammals and sea turtles;
      iii. Results of the protected species monitoring including numbers (by species if possible) of any marine mammals or sea turtles noted injured or killed as a result of the Long Range Strike Weapon Systems Evaluation Program mission and number of marine mammals or sea turtles (by species if possible) that may have been harassed due to presence within the zone of influence.

9 CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the ESA directs Federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of the threatened and endangered species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on ESA-listed species or critical habitat, to help implement recovery plans or develop information (50 CFR 402.02).

1. Monitor sighting, location, and stranding data for ESA-listed species in proximity to the action area.
2. Seek new information and higher quality data to validate assumptions used in acoustic modeling and risk analysis.

In order for NMFS' Office of Protected Resources ESA Interagency Cooperation Division to be kept informed of actions minimizing or avoiding adverse effects on, or benefiting, ESA-listed species or their critical habitat, Air Force should notify the ESA Interagency Cooperation Division of any conservation recommendations they implement in their final action.

10 Reinitiation of Consultation

This concludes formal consultation for the Air Force's operational evaluations of live long-range strike weapons and other munitions in the BSURE area of the PMRF off of the western shores of the island of Kauai in October 2016. As 50 CFR 402.16 states, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded, (2) new information reveals effects of the agency action that may affect ESA-listed species or critical habitat in a manner or to an extent not considered in this opinion, (3) the agency action is subsequently modified in a manner that causes an effect to the ESA-listed species or critical habitat that was not considered in this opinion, or (4) a new species is ESA-listed or critical habitat designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, the Air Force must contact the ESA Interagency Cooperation Division, Office of Protected Resources immediately.

11 References

Academies, N. R. C. o. t. N. 2008. Tackling marine debris in the 21st Century. Committee on the Effectiveness of International and National Measures to Prevent and Reduce Marine Debris and Its Impacts.

Ackerman, R. A. 1997. The nest environment and the embryonic development of sea turtles. Pages 83-106 *in* P. L. Lutz, and J. A. Musick, editors. The Biology of Sea Turtles. CRC Press, Boca Raton.

Arcangeli, A., and R. Crosti. 2009. The short-term impact of dolphin-watching on the behaviour of bottlenose dolphins (*Tursiops truncatus*) in western Australia. Journal of Marine Animals and their Ecology 2(1):3-9.

Arthur, R., N. Kelkar, T. Alcoverro, and M. D. Madhusudan. 2013. Complex ecological pathways underlie perceptions of conflict between green turtles and fishers in the Lakshadweep Islands. Biological Conservation 167:25-34.

Au, D., and W. Perryman. 1982. Movement and speed of dolphin schools responding to an approaching ship. Fishery Bulletin 80(2):371-379.

Avens, L., and K. Lohmann. 2003. Use of multiple orientation cues by juvenile loggerhead sea turtles *Caretta caretta*. Journal of Experimental Biology 206:4317–4325.

Baird, R. W. 2009. A review of false killer whales in Hawaiian waters: Biology, status, and risk factors. U.S. Marine Mammal Commission.

Baird, R. W., and coauthors. 2005. False killer whales around the main Hawaiian Islands: An assessment of inter-island movements and population size using individual photo-identification. (Pseudorca crassidens). Report prepared under Order No. JJ133F04SE0120 from the Pacific Islands Fisheries Science Center, National Marine Fisheries Service, 2570 Dole Street, Honolulu, HI 96822. 24pgs. 2005.

Baird, R. W., and coauthors. 2012a. Range and primary habitats of Hawaiian insular false killer whales: informing determination of critical habitat. Endangered Species Research 18(1):47-61.

Baird, R. W., and S. K. Hooker. 2000. Ingestion of plastic and unusual prey by a juvenile harbour porpoise. Marine Pollution Bulletin 40(8):719-720.

Baird, R. W., and coauthors. 2010. Movements and habitat use of satellite-tagged false killer whales around the main Hawaiian Islands. Endangered Species Research 10(1):107-121.

Baird, R. W., and coauthors. 2012b. Movements and Spatial Use of Odontocetes in the Western Main Hawaiian Islands: Results from Satellite-Tagging and Photo-Identification off Kaua'i and Ni'ihau in July/August 2011. Naval Postgraduate School; Department of Oceanography, Monterey, California.

Baker, J. D., C. L. Littnan, and D. W. Johnston. 2006. Potential effects of sea level rise on the terrestrial habitats of endangered and endemic megafauna in the Northwestern Hawaiian Islands. Endangered Species Research 2:21-30.

Balazs, G., and M. Chaloupka. 2006a. Recovery trend over 32 years at the Hawaiian green turtle rookery of French Frigate Shoals. Atoll Research Bulletin (543):147-158.

Balazs, G. H. 1979. Synopsis of biological data on the green turtle in the Hawaiian Islands.

Balazs, G. H. 1980. Synopsis of biological data on the green turtle in the Hawaiian Islands. U.S. Department of Commerce, Naitonal Oceanic and Atmospheric Administration, National Marine Fisheries Service.

Balazs, G. H. 1985. Impact of ocean debris on marine turtles: Entanglement and ingestion Pages 387-429 *in* R. S. Shomura, and H. O. Yoshida, editors. Workshop on the Fate and Impact of Marine Debris, Honolulu, Hawaii.

Balazs, G. H. 1995. Growth rates of immature green turtles in the Hawaiian Archipelago. Pages 117-125 *in* K. A. Bjorndal, editor. Biology and Conservation of Sea Turtles. Smithsonian Institution Press, Washington, D. C.

Balazs, G. H. 2000. Assessment of Hawaiian green turtles utilizing coastal foraging pastures at Palaau, Molokai. Pages 42-44 *in* K. A. Bjorndal, and A. B. Bolten, editors. Workshop on Assessing Abundance and Trends for In-water Sea Turtle Populations. National Oceanic and Atmospheric Administration, University of Florida, Gainesville, Florida.

Balazs, G. H., and M. Chaloupka. 2004. Thirty-year recovery trend in the once depleted Hawaiian green sea turtle stock. Biological Conservation 117(5):491-498.

Balazs, G. H., and M. Chaloupka. 2006b. Recovery trend over 32 years at the Hawaiian green turtle rookery at French Frigate Shoals. Atoll Research Bulletin 543:147-158.

Balazs, G. H., P. Craig, B. R. Winton, and R. K. Miya. 1994. Satellite telemetry of green turtles nesting at French Frigate Shoals, Hawaii, and Rose Atoll, American Samoa. Pages 184-187 *in* K. A. Bjorndal, A. B. Bolten, D. A. Johnson, and P. J. Eliazar, editors. Fourteenth Annual Symposium on Sea Turtle Biology and Conservation.

Balazs, G. H., and D. M. Ellis. 1996. Satellite telemetry of migrant male and female green turtles breeding in the Hawaiian Islands. Pages 281-283 *in* Sixteenth Symposium Proceedings Supplement.

Balazs, G. H., R. K. Miya, and S. C. Beavers. 1996. Procedures to attach a satellite transmitter to the carapace of an adult green turtle, *Chelonia mydas*. Pages 21-26 *in* J. A. Keinath, D. E. Barnard, J. A. Musick, and B. A. Bell, editors. Fifteenth Annual Symposium on Sea Turtle Biology and Conservation.

Balazs, G. H., and coauthors. 2005. Green turtle foraging and resting habitats at Midway Atoll: Significant findings over 25 years, 1975-2000. Pages 102-104 *in* M. C. Coyne, and R. D. Clark, editors. Twenty-First Annual Symposium on Sea Turtle Biology and Conservation.

Balcomb, K. C. 1987. The whales of Hawaii, including all species of marine mammals in Hawaiian and adjacent waters.Marine Mammal Fund Publication, San Francisco, CA. 99p.

Ballorain, K., and coauthors. 2013. Seasonal diving behaviour and feeding rhythms of green turtles at Mayotte Island. Marine Ecology Progress Series 483:289-302.

Barlow, J. 2006. Cetacean abundance in Hawaiian waters estimated from a summer/fall survey in 2002. Marine Mammal Science 22(2):446-464.

Bartol, S., J. Musick, and M. Lenhardt. 1999a. Auditory evoked potentials of the loggerhead sea turtle (*Caretta caretta*). Copeia 1999(3):836-840.

Bartol, S. M., and D. R. Ketten. 2006. Turtle and tuna hearing. Pages 98-103 *in* Y. Swimmer, and R. W. Brill, editors. Sea Turtle and Pelagic Fish Sensory Biology: Developing Techniques to Reduce Sea Turtle Bycatch in Longline Fisheries, volume Technical Memorandum NMFS-PIFSC-7. U.S Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Pacific Islands Fisheries Science Center.

Bartol, S. M., J. A. Musick, and M. Lenhardt. 1999b. Auditory Evoked Potentials of the Loggerhead Sea Turtle (*Caretta caretta*). Copeia 3:836-840.

Becker, N. M. 1995. Fate of selected high explosives in the environment: A literature review.

Bell, L. A. J., U. Fa'anunu, and T. Koloa. 1994. Fisheries resources profiles: Kingdom of Tonga, Honiara, Solomon Islands.

Benson, S. R., K. A. Forney, J. T. Harvey, J. V. Carretta, and P. H. Dutton. 2007. Abundance, distribution, and habitat of leatherback turtles (*Dermochelys coriacea*) off California, 1990−2003. Fishery Bulletin 105(3):337-347.

Berkson, H. 1967. Physiological adjustments to deep diving in the Pacific green turtle (*Chelonia mydas agassizii*). Comparative Biochemistry and Physiology A-Molecular and Integrative Physiology 21(3):507-524.

Bjorndal, K., and A. Bolten. 2000. Green turtles at Conception Island Creek, Bahamas. Pages 75-76 *in* K. A. Bjorndal, and A. B. Bolten, editors. Workshop on Assessing Abundance and Trends for In-water Sea Turtle Populations. National Oceanic and Atmospheric Administration, University of Florida, Gainesville, Florida.

Bjorndal, K. A. 1997. Foraging ecology and nutrition of sea turtles. Pages 199–231 *in* The Biology of Sea Turtles. CRC Press, Boca Raton, Florida.

Bjorndal, K. A., A. B. Bolten, and C. J. Lagueux. 1994a. Ingestion of marine debris by juvenile sea-turtles in coastal Florida habitats. Marine Pollution Bulletin 28(3):154-158.

Bjorndal, K. A., A. B. Bolten, and C. J. Lagueux. 1994b. Ingestion of marine debris by juvenile sea turtles in coastal Florida habitats. Marine Pollution Bulletin 28(3):154-158.

Bouchard, S., and coauthors. 1998. Effects of exposed pilings on sea turtle nesting activity at Melbourne Beach, Florida. Journal of Coastal Research 14(4):1343-1347.

Bowen, B. W., and coauthors. 2004. Natal homing in juvenile loggerhead turtles (*Caretta caretta*). Molecular Ecology 13:3797–3808.

Bradford, A., K. Forney, E. Oleson, and J. Barlow. 2013. Line-transect abundance estimates of cetaceans in the Hawaiian EEZ. PIFSC Working Paper WP-13-004.

Bradford, A. L., K. A. Forney, E. M. Oleson, and J. Barlow. In Review. Line-transect abundance estimates of cetaceans in the Hawaiian EEZ. Fisheries Bulletin.

Brill, R. W., and coauthors. 1995. Daily movements, habitat use, and submergence intervals of normal and tumor-bearing juvenile green turtles (*Chelonia mydas* L.) within a foraging area in the Hawaiian Islands. Journal of Experimental Marine Biology and Ecology 185(2):203-218.

Bugoni, L., L. Krause, and M. Virginia Petry. 2001. Marine debris and human impacts on sea turtles in southern Brazil. Marine Pollution Bulletin 42(12):pp. 1330-1334.

Cardona, L., P. Campos, Y. Levy, A. Demetropoulos, and D. Margaritoulis. 2010. Asynchrony between dietary and nutritional shifts during the ontogeny of green turtles (*Chelonia mydas*) in the Mediterranean. Journal of Experimental Marine Biology and Ecology 393(1-2):83-89.

Carr, A. 1987. Impact of nondegradable marine debris on the ecology and survival outlook of sea turtles. Marine Pollution Bulletin 18(6B):352-356.

Carr, A., M. H. Carr, and A. B. Meylan. 1978. The ecology and migration of sea turtles, 7. the west Caribbean turtle colony. Bulletin of the American Museum of Natural History, New York 162(1):1-46.

Carr, A. F. 1952. Handbook of Turtles: The Turtles of the United States, Canada and Baja California. Comstock Publishing Associates, Ithaca, New York.

Carretta, J. V., and coauthors. 2016. U.S. Pacific marine mammal stock assessments: 2015. N. M. F. S. National Oceanic and Atmospheric Administration, Southwest Fisheries Science Center., editor.

Carretta, J. V., and coauthors. 2010. U.S. Pacific Marine Mammal Stock Assessments: 2009. U.S. Department of Commerce, NOAA, NMFS Southwest Fisheries Science Center, La Jolla, CA.

Carretta, J. V., and coauthors. 2005. U.S. Pacific Marine Mammal Stock Assessments: 2004. U.S. Department of Commerce, NOAA-TM-NMFS-SWFSC-358.

Caut, S., E. Guirlet, and M. Girondot. 2009. Effect of tidal overwash on the embryonic development of leatherback turtles in French Guiana. Marine Environmental Research 69(4):254-261.

Chaloupka, M., G. H. Balazs, and T. M. Work. 2009. Rise and fall over 26 Years of a marine epizootic in Hawaiian green sea turtles. Journal of Wildlife Diseases 45(4):1138-1142.

Chaloupka, M., and coauthors. 2008a. Encouraging outlook for recovery of a once severely exploited marine megaherbivore. Global Ecology and Biogeography 17(2):297-304.

Chaloupka, M., D. Parker, and G. Balazs. 2008b. Modelling post-release mortality of pelagic loggerhead sea turtles exposed to the Hawaii-based pelagic longline fishery. Pages 55 *in* H. J. Kalb, A. Rohde, K. Gayheart, and K. Shanker, editors. Twenty-Fifth Annual Symposium on Sea Turtle Biology and Conservation.

Chaloupka, M., T. M. Work, G. H. Balazs, S. K. K. Murakawa, and R. Morris. 2008c. Cause-specific temporal and spatial trends in green sea turtle strandings in the Hawaiian Archipelago (1982-2003). Marine Biology 154(5):887-898.

Clarke, R. 1956. Marking whales from a helicopter. Proceedings of the Zoological Society of London 126:646.

Coston-Clements, L., and D. E. Hoss. 1983. Synopsis of data on the impact of habitat alteration on sea turtles around the southeastern United States. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Fisheries Center.

De Weede, R. E. 1996. The impact of seaweed introductions on biodiversity. Global Biodiversity 6:2-9.

DON. 2010. Letter regarding environmental impact statement/overseas environmental impact statement (EIS/OEIS) for Navy military readiness activitine in the Hawaii-Southern California training and testing (HSTT) study area. Department of the Navy, United States Pacific Fleet.

Doney, S. C., and coauthors. 2012. Climate change impacts on marine ecosystems. Marine Science 4.

Dutton, P. H., G. H. Balazs, and A. E. Dizon. 1998. Genetic stock identification of sea turtles caught in the Hawaii-based pelagic longline fishery. Pages 45-46 *in* S. P. Epperly, and J. Braun, editors. Seventeenth Annual Sea Turtle Symposium.

Eckert, K. L. 1993a. The biology and population status of marine turtles in the nothern Pacific Ocean. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center.

Eckert, K. L. 1993b. The Biology and Population Status of Marine Turtles in the Nothern Pacific Ocean. National Marine Fisheries Service.

Efroymson, R. A., W. H. Rose, S. Nemeth, and G. W. Suter II. 2000. Ecological risk assessment framework for low-altitude overflights by fixed-wing and rotary-wing military aircraft. Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Erbe, C. 2002. Underwater noise of whale-watching boats and potential effects on killer whales (*Orcinus orca*), based on an acoustic impact model. Marine Mammal Science 18(2):394-418.

Finkbeiner, E. M., and coauthors. 2011. Cumulative estimates of sea turtle bycatch and mortality in USA fisheries between 1990 and 2007. Biological Conservation.

Finneran, J. J., and A. K. Jenkins. 2012. Criteria and thresholds for U.S. Navy acoustic and explosive effects analysis. Department of Navy, San Diego, California.

Flint, M., and coauthors. 2009. Development and application of biochemical and haematological reference intervals to identify unhealthy green sea turtles (Chelonia mydas). The Veterinary Journal.

Force, D. o. t. A. 2016. Draft Environmental Assessment/Overseas Environmental Assessment for the Long Range Strike Weapon Systems Evaluation Program at the Pacific Missile Range Facility at Kauai, Hawaii.

Forney, K. A., R. W. Baird, and E. M. Oleson. 2010. Rationale for the 2010 revision of stock boundaries for the Hawaii insular and pelagic stocks of false killer whales, Pseudorca crassidens.

Francke, D. L. 2013. Marine Turtle Strandings in the Hawaiian Islands January - December 2012. P. S. D. Marine Turtle Research Program, NOAA Pacific Islands Fisheries Science Center, editor.

Frazier, J. G. 1980. Marine turtles and problems in coastal management. Pages 2395-2411 *in* B. L. Edge, editor. Coastal Zone '80: Proceedings of the Second Symposium on Coastal and Ocean Management, 3 edition. American Society of Civil Engineers, United States of America.

Frey, A., P. H. Dutton, and G. H. Balazs. 2013. Insights on the demography of cryptic nesting by green turtles (Chelonia mydas) in the main Hawaiian Islands from genetic relatedness analysis. Journal of Experimental Marine Biology and Ecology 442:80-87.

Fritts, T. H., and coauthors. 1983. Turtles, birds, and mammals in the northern Gulf of Mexico and nearby Atlantic waters. U.S. Fish and Wildlife Service, Division of Biological Services, Washington, D. C. .

Fuentes, M. M. P. B., M. Hamann, and C. J. Limpus. 2009a. Past, current and future thermal profiles of green turtle nesting grounds: Implications from climate change. Journal of Experimental Marine Biology and Ecology in press(in press):in press.

Fuentes, M. M. P. B., M. Hamann, and C. J. Limpus. 2010a. Vulnerability of sea turtles nesting grounds to climate change. Pages 65 *in* J. Blumenthal, A. Panagopoulou, and A. F. Rees, editors. Thirtieth Annual Symposium on Sea Turtle Biology and Conservation. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Fisheries Science Center, Goa, India.

Fuentes, M. M. P. B., C. J. Limpus, and M. Hamann. 2010b. Vulnerability of sea turtle nesting grounds to climate change. Global Change Biology in press(in press):in press.

Fuentes, M. M. P. B., and coauthors. 2009b. Proxy indicators of sand temperature help project impacts of global warming on sea turtles in northern Australia. Endangered Species Research 9:33-40.

Gabriele, C., B. Kipple, and C. Erbe. 2003. Underwater acoustic monitoring and estimated effects of vessel noise on humpback whales in Glacier Bay, Alaska. Pages 56-57 *in* Fifteenth Biennial Conference on the Biology of Marine Mammals, Greensboro, North Carolina.

Gambell, R. 1968. Aerial observations of sperm whale behaviour. Norsk Hvalfangst-Tidende 57(6):126-138.

Gambell, R. 1985a. Fin Whale *Balaenoptera physalus* (Linnaeus, 1758). Pages 171-192 *in* Handbook of Marine Mammals. Vol. 3: The Sirenians and Baleen Whales. Academic Press, London, U.K.

Gambell, R. 1985b. Sei whale, *Balaenoptera borealis* Lesson, 1828. Pages 155-170 *in* S. H. Ridway, and S. R. Harrison, editors. Handbook of Marine Mammals, volume 3: The Sirenians and Baleen Whales. Academic Press, London.

Glen, F., A. C. Broderick, B. J. Godley, and G. C. Hays. 2003. Incubation environment affects phenotype of naturally incubated green turtle hatchlings. Journal of the Marine Biological Association of the United Kingdom 83:1183-1186.

Green, G. A., and coauthors. 1992a. Cetacean distribution and abundance off Oregon and Washington, 1989-1990. Pages 100 *in* J. J. Brueggeman, editor. Oregon and Washington Marine Mammal and Seabird Surveys, volume OCS Study MMS 91-0093. Minerals Management Service, Los Angeles, California.

Green, G. A., and coauthors. 1992b. Cetacean distribution and abundance off Oregon and Washington, 1989-1990. Oregon and Washington Marine Mammal and Seabird Surveys. Minerals Management Service Contract Report 14-12-0001-30426.

Hain, J. H. W., M. A. M. Hyman, R. D. Kenney, and H. E. Winn. 1985. The role of cetaceans in the shelf-edge region of the Northeastern United States. Marine Fisheries Review 47(1):13-17.

Hatase, H., K. Omuta, and K. Tsukamoto. 2006a. Contrasting depth utilization by adult female loggerhead turtles around Japan during the foraging periods. Pages 93 *in* Twenty-Sixth Annual Conference on Sea Turtle Conservation and Biology.

Hatase, H., K. Sato, M. Yamaguchi, K. Takahashi, and K. Tsukamoto. 2006b. Individual variation in feeding habitat use by adult female green sea turtles (*Chelonia mydas*): Are they obligately neritic herbivores? Oecologia 149(1):52-64.

Hawkes, L. A., A. C. Broderick, M. H. Godfrey, and B. J. Godley. 2009. Climate change and marine turtles. Endangered Species Research 7:137-154.

Hays, G. C., S. Hochscheid, A. C. Broderick, B. J. Godley, and J. D. Metcalfe. 2000. Diving behaviour of green turtles: Dive depth, dive duration and activity levels. Marine Ecology Progress Series 208:297-298.

Hazel, J., I. R. Lawler, and M. Hamann. 2009. Diving at the shallow end: Green turtle behaviour in near-shore foraging habitat. Journal of Experimental Marine Biology and Ecology 371(1):84-92.

Hazel, J., I. R. Lawler, H. Marsh, and S. Robson. 2007. Vessel speed increases collision risk for the green turtle *Chelonia mydas*. Endangered Species Research 3:105-113.

Hazen, E. L., and coauthors. 2012. Predicted habitat shifts of Pacific top predators in a changing climate. Nature Climate Change Letters.

HDR. 2012. Summary Report: Compilation of Visual Survey Effort and Sightings for Marine Species Monitoring in the Hawaii Range Complex, 2005-2012. Prepared for Commander, U.S. Pacific Fleet, Pearl Harbor, Hawaii. Submitted to Naval Facilities Engineering Command Pacific (NAVFAC), EV2 Environmental Planning, Pearl Harbor, Hawaii, 96860-3134, under contract # N62470-10-D-3011, issued to HDR Inc., San Diego, California.

Heithaus, M. R., and L. M. Dill. 2002. Feeding strategies and tactics. Pages 412-422 *in* W. F. Perrin, B. Wursig, and J. G. M. Thewissen, editors. Encyclopedia of Marine Mammals. Academic Press, San Diego.

Hildebrand, J. A. 2005. Impacts of anthropogenic sound. Pages 101-124 *in* J. E. Reynolds, editor. Marine Mammal Research: Conservation Beyond Crisis. The John Hopkins University Press.

Hildebrand, J. A. 2009. Anthropogenic and natural sources of ambient noise in the ocean. Marine Ecology Progress Series 395:5-20.

Hirth, H. F. 1971. Synopsis of biological data on the green turtle *Chelonia mydas* (Linnaeus) 1758. Food and Agriculture Organization.

Hochscheid, S., F. Bentivegna, and G. C. Hays. 2005. First, records of dive durations for a hibernating sea turtle. Biology Letters 1(1):82-86.

Hodge, R. P., and B. L. Wing. 2000. Occurrences of marine turtles in Alaska Waters: 1960-1998. Herpetological Review 31(3):148-151.

Holst, M., and coauthors. 2011. Responses of pinnipeds to Navy missile launches at San Nicolas Island, California. Aquatic Mammals 37(2):139-150.

Holt, M. M., D. P. Noren, V. Veirs, C. K. Emmons, and S. Veirs. 2009. Speaking up: Killer whales (Orcinus orca) increase their call amplitude in response to vessel noise. Journal of the Acoustical Society of America 125(1):El27-El32.

Houghton, J. D. R., A. C. Broderick, B. J. Godley, J. D. Metcalfe, and G. C. Hays. 2002. Diving behaviour during the internesting interval for loggerhead turtles *Caretta caretta* nesting in Cyprus. Marine Ecology Progress Series 227:63-70.

Houtan, K. S. V., and J. M. Halley. 2011. Long-term climate forcing in loggerhead sea turtle nesting. PLoS ONE 6(4):e19043.

I-Jiunn, C. 2009. Changes in diving behaviour during the internesting period by green turtles. Journal of Experimental Marine Biology and Ecology 381(1):18-24.

IPCC. 2014. Climate change 2014: Impacts, adaptation, and vulnerability. IPCC Working Group II contribution to AR5. Intergovernmental Panel on Climate Change.

Ischer, T., K. Ireland, and D. T. Booth. 2009. Locomotion performance of green turtle hatchlings from the Heron Island Rookery, Great Barrier Reef. Marine Biology 156(7):1399-1409.

Johanos, T. C., and J. D. Baker. 2004. The Hawaiian monk seal in the northwestern Hawaiian Islands, 2001. (Monachus schauinslandi). NOAA Technical Memorandum NMFS-PIFSC-1, 147p.

Johnson, P. A., and B. W. Johnson. 1979. Hawaiian monk seal: Notes on reproductive behavior. Third Biennial Conference on the Biology of Marine Mammals, 7-11 October The Olympic Hotel Seattle WA. p.32.

Jones, T. T., and K. S. V. Houtan. 2014. Sea turtle tagging in the Mariana Islands Range Complex (MIRC) interim report. NOAA, NMFS, PIFSC.

Kamezaki, N., and coauthors. 2003. Loggerhead Turtles Nesting in Japan. Pages 210-217 *in* A. B. Bolten, and B. E. Witherington, editors. Loggerhead Sea Turtles. Smithsonian Institution.

Kasuya, T., and T. Miyashita. 1988. Distribution of sperm whale stocks in the North Pacific. Scientific Reports of the Whales Research Institute, Tokyo 39:31-75.

Keller, B. D., and coauthors. 2009. Climate change, coral reef ecosystems, and management options for marine protected areas. Environmental Management 44(6):1069-1088.

Kenyon, K. W. 1981. Monk seals, Monachus Fleming, 1822. Pages 195-220 *in* S. H. Ridgway, and R. J. Harrison, editors. Handbook of Marine Mammals: Seals, volume 2. Academic Press Inc. , London, UK.

Ketten, D. R. 1995. Estimates of blast injury and acoustic trauma zones for marine mammals from underwater explosions. Pages 391-407 *in* R. A. Kastelein, J. A. Thomas, and P. E. Nachtigall, editors. Sensory Systems of Aquatic Mammals. De Spil Publishers, Woerden.

Ketten, D. R. 1998. Marine mammal auditory systems: A summary of audiometroc and anatomical data and its implications for underwater acoustic impacts. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center.

Ketten, D. R., and S. M. Bartol. 2005. Functional Measures of Sea Turtle Hearing.

Ketten, D. R., and S. M. Bartol. 2006. Functional measures of sea turtle hearing. Office of Naval Research, Arlington, VA.

Kipple, B., and C. Gabriele. 2004. Underwater noise from skiffs to ships. J. F. Piatt, and S. M. Gende, editors. Fourth Glacier Bay Science Symposium.

Kittinger, J. N., K. S. V. Houtan, L. E. McClenachan, and A. L. Lawrence. 2013. Using historical data to assess the biogeography of population recovery. Ecography.

Kjeld, J. M. 1982. Hormones, electrolytes and other blood constituents in large whales. Unpublished paper to the IWC Scientific Committee. 4 pp. Cambridge, June (SC/34/O12).

Kolinski, S. 1991. Outer islands turtle project: Stage 1 Final report on the Olimarao Atoll fieldwork. Marine Resources Management Division, Yap, Federated States of Micronesia, March.

Koski, W. R., J. W. Lawson, D. H. Thomson, and W. J. Richardson. 1998. Point Mugu Sea Range marine mammal technical report. Naval Air Warfare Center, Weapons Division and Southwest Division, Naval Facilities Engineering Command.

Lagueux, C. J. 2001. Status and distribution of the green turtle, *Chelonia mydas*, in the wider Caribbean region. Pages 32-35 *in* K. L. Eckert, and F. A. Abreu Grobois, editors. Marine Turtle Conservation in the Wider Caribbean Region - A Dialogue for Effective Regional Management, Santo Domingo, Dominican Republic.

Lagueux, C. J., C. L. Campbell, and S. Strindberg. 2014. Artisanal green turtle, *Chelonia mydas*, fishery of Caribbean Nicaragua: I. Catch rates and trends, 1991-2011. PLoS ONE 9(4):e94667.

Lenhardt, M. L., R. C. Klinger, and J. A. Musick. 1985. Marine turtle middle-ear anatomy. Journal of Auditory Research 25(1):66-72.

Lenhardt, M. L., S. E. Moein, J. A. Musick, and D. E. Barnard. 1994. Evaluation of the Response of Loggerhead Sea Turtles (Caretta caretta) to a Fixed Sound Source. Draft Final Report Submitted to the U.S. Army Corps of Engineers, Waterways Experiment Station:13.

Limpus, C., and M. Chaloupka. 1997. Nonparametric regression modelling of green sea turtle growth rates (southern Great Barrier Reef). Marine Ecology Progress Series 149:23-34.

Lipman, V., and G. Balazs. 1983. The lost Hawaiian Island. Honolulu Magazine 18(5):82-87.

Littman, C. 2011. Habitat Use and Behavioral Monitoring of Hawaiian Monk Seals in Proximity to the Navy Hawaii Range Complex. Report Period: August 2010-July 2011. H. a. m. r. f. Appendix M, submitted to National Marine Fisheries Service, editor.

Littnan, C. 2011. Habitat Use and Behavioral Monitoring of Hawaiian Monk Seals in Proximity to the Navy Hawaii Range Complex. Report Period: August 2010-July 2011: Appendix M, HRC annual monitoring report for 2011, submitted to National Marine Fisheries Service.

Lohmann, K. J., and C. M. F. Lohmann. 1996a. Detection of magnetic field intensity by sea turtles. Nature 380:59-61.

Lohmann, K. J., and C. M. F. Lohmann. 1996b. Orientation and open-sea navigation in sea turtles. Journal of Experimental Biology 199(1):73-81.

Luksenburg, J. A., and E. C. M. Parsons. 2009a. The effects of aircraft on cetaceans: Implications for aerial whalewatching. Sixty First Meeting of the International Whaling Commission, Madeira, Portugal.

Luksenburg, J. A., and E. C. M. Parsons. 2009b. The effects of aircraft on cetaceans: implications for aerial

whalewatching. Unpublished report to the International Whaling Commission.

Lutcavage, M. E., P. L. Lutz, G. D. Bossart, and D. M. Hudson. 1995. Physiologic and clinicopathologic effects of crude oil on loggerhead sea turtles. Archives of Environmental Contamination and Toxicology 28(4):417-422.

Lutcavage, M. E., P. Plotkin, B. E. Witherington, and P. L. Lutz. 1997. Human impacts on sea turtle survival. Pages 387-409 *in* P. L. Lutz, and J. A. Musick, editors. The Biology of Sea Turtles. CRC Press, New York, New York.

Manci, K. M., D. N. Gladwin, R. Villella, and M. G. Cavendish. 1988. Effects of aircraft noise and sonic booms on domestic animals and wildlife: A literature synthesis. U.S. Fish and Wildlife Service, National Ecology Research Center, Ft. Collins, Colorado.

Márquez, M. R. 1990. Sea turtles of the world. An annotated and illustrated catalogue of sea turtle species known to date.

Masaki, Y. 1977. The separation of the stock units of sei whales in the North Pacific. Report of the International Whaling Commission (Special Issue 1):71-79.

McCracken, M. L. 2000. Estimation of sea turtle take and mortality in the Hawaiian longline fisheries.

McKenna, M. F., D. Ross, S. M. Wiggins, and J. A. Hildebrand. 2012. Underwater radiated noise from modern commercial ships. Journal of the Acoustical Society of America 131(2):92-103.

McKenna, M. F., S. M. Wiggins, and J. A. Hildebrand. 2013. Relationship between container ship underwater noise levels and ship design, operational and oceanographic conditions. Scientific reports 3.

McKenzie, C., B. J. Godley, R. W. Furness, and D. E. Wells. 1999. Concentrations and patterns of organochlorine contaminants in marine turtles from Mediterranean and Atlantic waters. Marine Environmental Research 47:117-135.

McMahon, C. R., and G. C. Hays. 2006. Thermal niche, large-scale movements and implications of climate change for a critically endangered marine vertebrate. Global Change Biology 12(7):1330-1338.

Meylan, A. B., B. W. Bowen, and J. C. Avise. 1990. A genetic test of the natal homing versus social facilitation models for green turtle migration. Science 248(4956):724-727.

Mizroch, S. A., D. W. Rice, D. Zwiefelhofer, J. Waite, and W. L. Perryman. 1999a. Distribution and movements of fin whales (Balaenoptera physalus) in the Pacific Ocean. Thirteenth Biennial Conference on the Biology of Marine Mammals, Wailea, Hawaii.

Mizroch, S. A., D. W. Rice, D. Zwiefelhofer, J. Waite, and W. L. Perryman. 1999b. Distribution and movements of fin whales (Balaenoptera physalus) in the Pacific Ocean. Thirteen Biennial Conference on the Biology of Marine Mammals, 28 November - 3 December Wailea Maui HI. p.127.

MMC. 2007. Marine mammals and noise: A sound approach to research and management. Marine Mammal Commission.

Mobley Jr., J. R., S. S. Spitz, K. A. Forney, R. Grotefendt, and P. H. Forestell. 2000. Distribution and abundance of odontocete species in Hawaiian waters: Preliminary results of 1993-98 aerial surveys. NOAA, NMFS, SWFSC Administrative Report LJ-00-14C. 27p.

Moein Bartol, S., and D. R. Ketten. 2006. Turtle and tuna hearing. Pp.98-103 In: Swimmer, Y. and R. Brill (Eds), Sea Turtle and Pelagic Fish Sensory Biology: Developing Techniques to Reduce Sea Turtle Bycatch in Longline Fisheries. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-PIFSC-7.

Moein Bartol, S., and J. A. Musick. 2003. Sensory biology of sea turtles. Pages 90-95 *in* P. L. Lutz, J. A. Musick, and J. Wyneken, editors. The Biology of Sea Turtles, volume II. CRC Press, Boca Raton, Florida.

Moein, S. E. 1994. Auditory evoked potentials of the loggerhead sea turtle (*Caretta caretta*). College of William and Mary, Williamsburg.

Moore, C. J., S. L. Moore, M. K. Leecaster, and S. B. Weisberg. 2001. A comparison of plastic and plankton in the North Pacific Central Gyre. Marine Pollution Bulletin 42(12):1297-1300.

Mullin, K. D., and coauthors. 1991. Whales and dolphins offshore of Alabama. Journal of the Alabama Academy of Science 62(1):48-58.

Murakawa, S. K. K., G. H. Balazs, D. M. Ellis, S. Hau, and S. M. Eames. 2000. Trends in fibropapillomatosis among green turtles stranded in the Hawaiian Islands, 1982-98. K. H.

J., and T. Wibbels, editors. Nineteenth Annual Symposium on Sea Turtle Biology and Conservation.

Musick, J. A., and C. J. Limpus. 1997. Habitat utilization and migration in juvenile sea turtles. Pages 137-163 *in* P. L. Lutz, and J. A. Musick, editors. The Biology of Sea Turtles. CRC Press, New York, New York.

Navy. 2011. Marine Species Monitoring for the U.S. Navy's Hawaii Range Complex 2011. Department of the Navy, U.S. Pacific Fleet.

Navy, U. S. D. o. t. 2013. Hawaii-Southern California Training and Testing EIS/OEIS.

Navy, U. S. D. o. t. 2014. Commander Task Force 3rd and 7th Fleet Navy Marine Species Density Database. NAVFAC Pacific Technical Report. N. F. E. C. Pacific, editor, Pearl Harbor, HI.

Navy, U. S. D. o. t. 2016. DRAFT U.S. Navy Marine Species Density Database Phase III for the Hawaii-Southern California Training and Testing Study Area. NAVFAC Pacific Technical Report. Pages 270 pp. *in* N. F. E. C. Pacific, editor, Pearl Harbor, HI.

NMFS. 1998. Draft recovery plan for the blue whale (*Balaenoptera musculus*). National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources, Silver Spring, Maryland.

NMFS. 2005. Hawaii-based Pelagic, Deep-Set Tuna Longline Fishery based on the Fishery Management Plan for Pelagic Fisheries of the Western Pacific Region.

NMFS. 2008. March 18, 2008, biological opinion on effects of Implementation of Bottomfish Fishing Regulations within Federal Waters of the Main Hawaiian Islands on ESA-listed marine species. Pacific Islands Regional Office:35 p.

NMFS. 2012. Biological opinion on the continued operation of the Hawaiian-based shallow-set longline swordfish fishery - under Amendment 18 to the Fishery Management Plan for Pelagic Fisheries of the Western Pacific Region. Pages p. 162 *in* P. I. R. Office, editor.

NMFS, and USFWS. 1993. Recovery plan for the hawksbill turtle in the U.S. Caribbean Sea, Atlantic Ocean, and Gulf of Mexico, St. Petersburg, Florida.

NMFS, and USFWS. 1998a. Recovery Plan for the U.S. Pacific Populations of the Leatherback Turtles (*Dermochelys coriacea*). Silver Spring, Maryland.

NMFS, and USFWS. 1998b. Recovery Plan for U.S. Pacific Populations of the East Pacific Green Turtle (*Chelonia mydas*). National Marine Fisheries Service and U.S. Fish and Wildlife Service, Silver Spring, Maryland.

NMFS, and USFWS. 1998c. Recovery plan for U.S. Pacific populations of the green turtle (*Chelonia mydas*). National Marine Fisheries Service and U.S. Fish and Wildlife Service, Silver Spring, Maryland.

NMFS, and USFWS. 1998d. Recovery Plan for U.S. Pacific Populations of the Loggerhead Turtle (*Caretta caretta*), Silver Spring, Maryland.

NMFS, and USFWS. 2007a. Green Sea Turtle (*Chelonia mydas*) 5-Year Review: Summary and Evaluation National Marine Fisheries Service and U.S. Fish and Wildlife Service, Silver Spring, MD.

NMFS, and USFWS. 2007b. Leatherback sea turtle (*Dermochelys coriacea*) 5-year review: Summary and evaluation. National Marine Fisheries Service and U.S. Fish and Wildlife Service, Silver Spring, Maryland.

Noren, D. P., A. H. Johnson, D. Rehder, and A. Larson. 2009. Close approaches by vessels elicit surface active behaviors by southern resident killer whales. Endangered Species Research 8(3):179-192.

Normandeau Associates, I. a. A., Ltd. Joint Venture. 2013. Aerial Survey of Seabird and Marine Mammals at Ka'ula Island, Hawaii, Spring 2013. P. F. N. P. p. Prepared for Commander, editor.

Northrop, J., W. C. Cummings, and M. F. Norrison. 1971. Underwater 20-Hz signals recorded near Midway Island. Journal of the Acoustical Society of America 49(6, pt. 2):1909-1910.

Northrop, J. W., C. Cummings, and P. O. Thompson. 1968. 20-Hz signals observed in the central Pacific. Journal of the Acoustical Society of America 43:383-384.

Nowacek, D. P., L. H. Thorne, D. W. Johnston, and P. L. Tyack. 2007. Responses of cetaceans to anthropogenic noise. Mammal Review 37(2):81-115.

NRC. 2003. Ocean Noise and Marine Mammals. National Academies Press.

NRC. 2005. Marine mammal populations and ocean noise. Determining when noise causes biologically significant effects. National Academy of Sciences, Washington, D. C.

Oleson, E. M., and coauthors. 2010. Status Review of Hawaiian Insular False Killer Whales (Pseudorca crassidens) under the Endangered Species Act. Pacific Islands Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce.

Parker, D. M., G. H. Balazs, C. King, L. Katahira, and W. Gilmartin. 2009. Short-range movements of hawksbill turtles (*Eretmochelys imbricata*) from nesting to foraging areas within the Hawaiian Islands. Pacific Science 63(3):371-382.

Parker, D. M., W. J. Cooke, and G. H. Balazs. 2005. Diet of oceanic loggerhead sea turtles (*Caretta caretta*) in the central North Pacific. Fishery Bulletin 103:142-152.

Patenaude, N. J., and coauthors. 2002. Aircraft sound and disturbance to bowhead and beluga whales during spring migration in the Alaskan Beaufort Sea. Marine Mammal Science 18(2):309-335.

Perry, S. L., D. P. DeMaster, and G. K. Silber. 1999. The great whales: History and status of six species listed as endangered under the U.S. Endangered Species Act of 1973. Marine Fisheries Review 61(1):1-74.

Pike, D. A. 2009. Do green turtles modify their nesting seasons in response to environmental temperatures? Chelonian Conservation and Biology 8(1):43-47.

Piniak, W. E. D., D. A. Mann, S. A. Eckert, and C. A. Harms. 2012. Amphibious hearing in sea turtles. Advances in Experimental Medicine and Biology 730:83-87.

Plotkin, P. T. 2003. Adult migrations and habitat use. Pages 225-241 *in* P. L. Lutz, J. A. Musick, and J. Wyneken, editors. The Biology of Sea Turtles, volume 2. CRC Press.

Plotkin, P. T. 2007. Biology and Conservation of Ridley Sea Turtles. The Johns Hopkins University Press, Baltimore, MD.

Poloczanska, E. S., C. J. Limpus, and G. C. Hays. 2009. Vulnerability of marine turtles to climate change. Pages 151-211 *in* D. W. Sims, editor. Advances in Marine Biology, volume 56. Academic Press, Burlington, Vermont.

Pritchard, P. C. H. 1971. The leatherback or leathery turtle, Dermochelys coriacea. International Union for the Conservation of Nature, Monograph 1:39 pp.

Pritchard, P. C. H., and P. Trebbau. 1984. The turtles of Venezuela. SSAR.

Reeves, R. R., T. D. Smith, E. A. Josephson, P. J. Clapham, and G. Woolmer. 2004. Historical observations of humpback and blue whales in the North Atlantic Ocean: Clues to migratory routes and possibly additional feeding grounds. Marine Mammal Science 20(4):774-786.

Reeves, R. R., B. S. Stewart, and S. Leatherwood. 1992. The Sierra Club handbook of seals and sirenians. Sierra Club Books. San Francisco, CA. 359pgs. ISBN 0-87156-656-7.

Rice, M., and G. Balazs. 2008a. Diving behavior of the Hawaiian green turtle (*Chelonia mydas*) during oceanic migrations. Journal of Experimental Marine Biology and Ecology 356(1-2):121-127.

Rice, M. R., and G. H. Balazs. 2008b. Hawaiian green turtles dive to record depths during oceanic migrations. Pages 61 *in* K. Dean, and M. C. L. Castro, editors. Twenty-Eighth Annual Symposium on Sea Turtle Biology and Conservation. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Fisheries Science Center, Loreto, Baja California Sur, Mexico.

Richardson, W. J., C. R. G. Jr., C. I. Malme, and D. H. Thomson. 1995. Marine Mammals and Noise. Academic Press, Inc., San Diego, California.

Richter, C., S. Dawson, and E. Slooten. 2006. Impacts of commercial whale watching on male sperm whales at Kaikoura, New Zealand. Marine Mammal Science 22(1):46-63.

Richter, C. F., S. M. Dawson, and E. Slooten. 2003a. Sperm whale watching off Kaikoura, New Zealand: Effects of current activities on surfacing and vocalisation patterns. Science for Conservation 219.

Richter, C. F., S. M. Dawson, and E. Slooten. 2003b. Sperm whale watching off Kaikoura, New Zealand: Effects of current activities on surfacing and vocalisation patterns. Department of Conservation, Wellington, New Zealand. Science For Conservation 219. 78p.

Ridgway, S. H., E. G. Wever, J. G. McCormick, J. Palin, and J. H. Anderson. 1969. Hearing in the giant sea turtle, Chelonoa mydas. Proceedings of the National Academies of Science 64.

Rivers, J. 2011. Marine species monitoring for the U.S. Navy's Mariana Islands Range Complex: Annual report. 8 April 2011 Department of the Navy, Commander, U.S. Pacific Fleet.

Rosen, G., and G. R. Lotufo. 2010. Fate and effects of composition B in multispecies marine exposures. Environmantal Toxicology and Chemistry 29(6):1330-1337.

Ross, D. 1976. Mechanics of Unterwater Noise. Pergamon Press, New York.

Sarmiento-Ramırez, J. M., and coauthors. 2014. Global distribution of two fungal pathogens threatening endangered sea turtles. PLoS ONE 9(1):e85853.

Saski, H., and coauthors. 2013. Habitat differentiation between sei (*Balaenoptera borealis*) and Bryde’s whales (*B. brydei*) in the western North Pacific. Fisheries Oceanography 22(6):496-508.

Schuyler, Q., B. D. Hardesty, C. Wilcox, and K. Townsend. 2013. Global analysis of anthropogenic debris ingestion by sea turtles. Conservation Biology.

Seminoff, J. A. 2004. 2004 global status assessment: Green turtle (*Chelonia mydas*). The World Conservation Union (International Union for Conservation of Nature and Natural Resources), Species Survival Commission Red List Programme, Marine Turtle Specialist Group.

Seminoff, J. A., A. Resendiz, and W. J. Nichols. 2002. Diet of east pacific green turtles (*Chelonia mydas*) in the central Gulf of California, Mexico. Journal of Herpetology 36(3):447-453.

Senko, J., M. C. López-Castro, V. Koch, and W. J. Nichols. 2010. Immature east Pacific green turtles (*Chelonia mydas*) use multiple foraging areas off the Pacific coast of Baja California Sur, Mexico: First evidence from mark-recapture data. Pacific Science 64(1):125-130.

Senko, J., A. Mancini, J. A. Seminoff, and V. Koch. 2014. Bycatch and directed harvest drive high green turtle mortality at Baja California Sur, Mexico. Biological Conservation 169:24-30.

Shallenberger, E. W. 1981a. The status of Hawaiian cetaceans. Marine Mammal Commission.

Shallenberger, E. W. 1981b. The status of Hawaiian cetaceans. Final report to U.S. Marine Mammal Commission. MMC-77/23.

Simmonds, M. P., and S. J. Isaac. 2007. The impacts of climate change on marine mammals: Early signs of significant problems. Oryx 41(1):19-26.

Skillman, R. A., and G. H. Balazs. 1992. Leatherback turtle captured by ingestion of squid bait on swordfish longline. Fishery Bulletin 90:807-808.

Skillman, R. A., and P. Kleiber. 1998. Estimation of sea turtle take and mortality in the Hawai'i-based longline fishery, 1994-96. NOAA, SWFSC.

Smith, S. 2010. Sea turtles in Pearl Harbor. K. Kelly, editor. Tetra Tech, Inc., Honolulu, Hawaii.

Smultea, M. A., J. R. Mobley Jr., D. Fertl, and G. L. Fulling. 2008. An unusual reaction and other observations of sperm whales near fixed-wing aircraft. Gulf and Caribbean Research 20:75-80.

Stafford, K. M., and coauthors. 2004. Antarctic-type blue whale calls recorded at low latitudes in the Indian and eastern Pacific Oceans. Deep Sea Research Part I: Oceanographic Research Papers 51(10):1337-1346.

Stamper, M. A., C. W. Spicer, D. L. Neiffer, K. S. Mathews, and G. J. Fleming. 2009. Morbidity in a juvenile green sea turtle (*Chelonia mydas*) due to ocean-borne plastic. Journal of Zoo and Wildlife Medicine 40(1):196-198.

Storelli, M. M., and G. O. Marcotrigiano. 2003. Heavy metal residues in tissues of marine turtles. Marine Pollution Bulletin 46(4):397-400.

TEWG. 2009. An assessment of the loggerhead turtle population in the western North Atlantic ocean. Turtle Expert Working Group (TEWG), NMFS-SEFSC-575.

Thompson, P. O., and W. A. Friedl. 1982a. A long term study of low frequency sound from several species of whales off Oahu, Hawaii. Cetology 45:1-19.

Thompson, P. O., and W. A. Friedl. 1982b. A long term study of low frequency sounds from several species of whales off Oahu, Hawaii. Cetology 45:1-19.

Tomich, P. Q. 1986. Mammals in Hawai'I: A synopsis and notational bibliography. Bishop Museum Special Publication 76. Bishop Museum Press, Honolulu, Hawai'I. p.51-88, 104-110, 192-199. (Marine mammal sections).

Tourinho, P. S., J. A. I. d. Sul, and G. Fillmann. 2009. Is marine debris ingestion still a problem for the coastal marine biota of southern Brazil? Marine Pollution Bulletin in press(in press):in press.

Van Houtan, K. S., and O. L. Bass. 2007. Stormy oceans are associated with declines in sea turtle hatching. Current Biology 17(15):R590-R591.

Van Houtan, K. S., S. K. Hargrove, and G. H. Balazs. 2010. Land use, macroalgae, and a tumor-forming disease in marine turtles. PLoS ONE 5(9).

Viada, S. T., and coauthors. 2008. Review of potential impacts to sea turtles from underwater explosive removal of offshore structures. Environmental impact assessment review 28:267–285.

Waring, G. T. 1993. Spatial patterns of six cetaceans along a linear habitat. Tenth Biennial Conference on the Biology of Marine Mammals, 11-15 November Galveston TX. p.2. Symposium: Cetacean Habitats.

Waring, G. T., R. M. Pace, J. M. Quintal, C. P. Fairfield, and K. Maze-Foley. 2004. U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments - 2003, Woods Hole, Massachusetts.

Watkins, W. A., M. A. Daher, J. E. George, and S. Haga. 2000a. Distribution of calling blue, fin, and humpback whales in the North Pacific. Woods Hole Oceanographic Institution.

Watkins, W. A., and coauthors. 2000b. Seasonality and distribution of whale calls in the North Pacific. Oceanography 13(1):62-67.

Watkins, W. A., and coauthors. 2000c. Whale call data for the North Pacific November 1995 through July 1999 occurrence of calling whales and source locations from SOSUS and other acoustic systems. Woods Hole Oceanographic Institution.

Watters, D. L., M. M. Yoklavich, M. S. Love, and D. M. Schroeder. 2010. Assessing marine debris in deep seafloor habitats off California. Marine Pollution Bulletin 60:131-138.

Wells, R. S., and coauthors. 2008. Consequences of injuries on survival and reproduction of common bottlenose dolphins (Tursiops truncatus) along the west coast of Florida. Marine Mammal Science 24(4):774-794.

Wever, E. G. 1978. The Reptile Ear: Its Structure and Function. Princeton University Press, Princeton, New Jersey.

Wilkinson, C., and D. Souter. 2008. Status of Caribbean coral reefs after bleaching and hurricanes in 2005. Global Coral Reef Monitoring Network and Reef and Rainforest Research Centre, Townsville.

Williams Jr., E. H., and coauthors. 1994. An epizootic of cutaneous fibropapillomas in green turtles *Chelonia mydas* of the Caribbean: Part of a panzootic? Journal of Aquatic Animal Health 6:70-78.

Williams, S. L. 1988. *Thalassia testudinum* productivity and grazing by green turtles in a highly disturbed seagrass bed. Marine Biology 98:447-455.

Wilson, K., and A. D'Amico. 2012. Habitat Use and Behavioral Monitoring of Hawaiian Monk Seals in Proximity to the Navy Hawaii Range Complex. SPAWAR Systems Center, Pacific.

Witherington, B., S. Hirama, and A. Moiser. 2003. Effects of beach armoring structures on marine turtle nesting. U.S. Fish and Wildlife Service.

Witherington, B., S. Hirama, and A. Moiser. 2007. Changes to armoring and other barriers to sea turtle nesting following severe hurricanes striking Florida beaches. U.S. Fish and Wildlife Service.

Witherington, B. E. 1992. Behavioral responses of nesting sea turtles to artificial lighting. Herpetologica 48(1):31-39.

Witherington, B. E., and K. A. Bjorndal. 1991. Influences of artificial lighting on the seaward orientation of hatchling loggerhead turtles *Caretta caretta*. Biological Conservation 55(2):139-149.

Witzell, W. N. 1981. Predation on Juvenile Green Sea Turtles, Chelonia mydas , By a Grouper, Promicrops lanceolatus (Pisces: Serranidae) in the Kingdom of Tonga, South Pacific. Bulletin of Marine Science. Vol. 31:no. 4.

Witzell, W. N. 1983. Synopsis of biological data on the hawksbill sea turtle, *Eretmochelys imbricata* (Linnaeus, 1766). Food and Agricultural Organization of the United Nations, Rome.

Work, P. A., A. L. Sapp, D. W. Scott, and M. G. Dodd. 2010. Influence of small vessel operation and propulsion system on loggerhead sea turtle injuries. Journal of Experimental Marine Biology and Ecology.

Work, T. M., and coauthors. 2009. In vitro biology of fibropapilloma-associated turtle herpesvirus and host cells in Hawaiian green turtles (*Chelonia mydas*). Journal of General Virology 90:1943-1950.

Wursig, B., S. K. Lynn, T. A. Jefferson, and K. D. Mullin. 1998. Behaviour of cetaceans in the northern Gulf of Mexico relative to survey ships and aircraft. Aquatic Mammals 24(1):41-50.

Long Range Strike WSEP LOA Request with Cover Letter (June 22, 2016)

DEPARTMENT OF THE AIR FORCE
AIR FORCE CIVIL ENGINEER CENTER
JOINT BASE SAN ANTONIO LACKLAND TEXAS

AFCEC/CZN
2261 Hughes Ave., Ste. 155
JBSA Lackland, TX 78236-9853

22 June, 2016

Ms. Jolie Harrison
Division Chief, Office of Protected Resources
National Marine Fisheries Service
1315 East-West Highway, Room 13805
Silver Spring, MD 20910-3226

SUBJECT: Submission of the Request for a Letter of Authorization for the Incidental Taking of Marine Mammals Resulting from Long Range Strike Weapon Systems Evaluation Program at the Pacific Missile Range Facility at Kauai, Hawaii

Dear Ms. Harrison,

This letter and attached document is being submitted to the National Marine Fisheries Service to request a Letter of Authorization (LOA) in accordance with Section 101(a)(5)(A) of the Marine Mammal Protection Act of 1972 (MMPA) for activities described under the Preferred Alternative in the Long Range Strike Weapon Systems Evaluation Program (WSEP) Environmental Assessment/Overseas Environmental Assessment (EA/OEA). The LOA Request analyzes potential impacts to 25 marine mammal species and associated stocks resulting from Long Range Strike WSEP mission activities proposed for 2017 – 2021.

The Proposed Action would authorize the 86th Fighter Weapon Squadron (86 FWS) to conduct operational evaluations of long range strike weapons and other munitions at the Pacific Missile Range Facility, offshore of Kauai, Hawaii. Live (explosive) and inert (non-explosive) munitions would be released from multiple types of operation aircraft, including bombers and fighter aircraft, within military controlled airspace over the Pacific Ocean. The weapon impact point is approximately 44 nautical miles (NM) from the shore of Kauai within the Barking Sands Underwater Range Extension area. All weapons would impact the water surface, with live ordnance detonating on the water surface, or just below the water surface (approximately 10 feet deep). Net explosive weight for live ordnance ranges from 23 to 300 pounds. The water depth at the weapon impact location is over 4,600 meters.

On behalf of the 86 FWS, the Air Force Civil Engineering Center (AFCEC) is requesting small numbers of takes of two marine mammal species by Level A harassment, 16 marine mammal species by Level B Harassment, and 17 marine mammal species by Level B Behavioral Harassment, as defined by the MMPA. No mortality takes of any marine mammal species are anticipated. Long-term impacts to stocks and marine mammal populations are not anticipated.

Adherence to mitigation measures in Chapter 11 of the LOA Request is expected to further reduce the potential for adverse impacts on marine mammal populations and associated stocks. While the AFCEC is facilitating completion of environmental documentation and analysis, the action proponent and responsible party for conducting Long Range Strike WSEP missions at PMRF is the 86 FWS, therefore the LOA should be issued to the Commander of the 86 FWS, Lt. Colonel Sean Nietzke. Ultimately the 86 FWS will be responsible for adhering to the terms and conditions of the LOA upon its issuance.

If you have any questions regarding this LOA Request or any of the proposed activities, please do not hesitate to contact either Ms. Amanda Robydek at (850) 882-8395; amanda.robydek.ctr@us.af.mil or myself at (210) 925-2741; michael.ackerman.2@us.af.mil

Sincerely,

Michael D Ackerman

Michael Ackerman
Program Manager
NEPA Division (AFCEC/CZN)

ATTACHMENT: Request for a Letter of Authorization for the Incidental Taking of Marine Mammals Resulting from Long Range Strike Weapon Systems Evaluation Program at the Pacific Missile Range Facility at Kauai, Hawaii

CC: Lt. Col. Sean B. Neitzke, Commander, 86 Fighter Weapon Squadron

REQUEST FOR A LETTER OF AUTHORIZATION FOR THE INCIDENTAL TAKING OF MARINE MAMMALS RESULTING FROM LONG RANGE STRIKE WEAPON SYSTEMS EVALUATION PROGRAM AT THE PACIFIC MISSILE RANGE FACILITY AT KAUAI, HAWAII

Submitted To:

Office of Protected Resources
National Marine Fisheries Service (NMFS)
1315 East-West Highway
Silver Spring, MD 20910-3226

Submitted By:

Department of the Air Force

June 2016

This page is intentionally blank.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

GLOSSARY OF ACRONYMS, ABBREVIATIONS, AND SYMBOLS

≤	less than or equal to
>	greater than
°	degrees
° N	degrees North
° S	degrees South
° W	degrees West
86 FWS	86th Fighter Weapons Squadron
AFB	Air Force Base
AFCEC	Air Force Civil Engineer Center
Air Force	U.S. Air Force
BSURE	Barking Sands Underwater Range Extension
CFR	Code of Federal Regulations
CV	coefficient of variation
D	water depth (meters)
dB	decibels
dB re 1 μPa	decibels referenced to 1 micropascal
dB re 1 μPa @ 1 m	decibels referenced to 1 micropascal at 1 meter
dB re 1 $\mu Pa^2 \cdot s$	decibels referenced to 1 micropascal-squared second
DoD	Department of Defense
DPS	distinct population segment
EA	Environmental Assessment
EA/OEA	Environmental Assessment/Overseas Environmental Assessment
EEZ	Exclusive Economic Zone
ER	Extended Range
ESA	Endangered Species Act of 1973
FTS	flight termination system
GI	gastrointestinal
GPS	Global Positioning System
HARM	High-Speed Anti-Radiation Missile
HICEAS	Hawaiian Islands Cetacean and Ecosystem Assessment
HRC	Hawaii Range Complex
Hz	hertz
IADS	integrated air defense system
IHA	Incidental Harassment Authorization
INS	internal navigation system
JASSM	Joint Air-to-Surface Stand-off Missile
JASSM-ER	Joint Air-to-Surface Stand-Off Missile-Extended Range
JB	Joint Base
JDAM	Joint Direct Attack Munition
kg	kilograms
kHz	kilohertz
km	kilometers
km^2	square kilometers
lb	pounds
LJDAM	Laser Joint Direct Attack Munition
LOA	Letter of Authorization
m	meters
M	animal mass based on species (kilograms)
MALD	Miniature Air Launched Decoy
MALD-J	Miniature Air Launched Decoy–Jamming
MHI	Main Hawaiian Islands
mi^2	square miles

MMPA	Marine Mammal Protection Act
MSL	mean sea level
n/a	not available
N/A	not applicable
NAS	Naval Air Station
NEW	net explosive weight
NM	nautical miles
NM^2	square nautical miles
NMFS	National Marine Fisheries Service
NMSDD	Navy Marine Species Density Database
NOAA	National Oceanic and Atmospheric Administration
NOTAM	Notice to Airmen
NOTMAR	Notice to Mariners
OEA	Overseas Environmental Assessment
Pa	Pascal
Pa·s	pascal-seconds
PBX	plastic bonded explosive
PMRF	Pacific Missile Range Facility
psi·msec	pounds per square inch per millisecond
PTS	permanent threshold shift
SDB	Small Diameter Bomb
SDB-I/II	Small Diameter Bomb-I/II
SEL	sound exposure level
SPL	sound pressure level
TM	telemetry
TNT	2,4,6-trinitrotoluene
TTS	temporary threshold shift
USC	United States Code
USFWS	U.S. Fish and Wildlife Service
W-	Warning Area
WSEP	Weapon Systems Evaluation Program

EXECUTIVE SUMMARY

With this submittal, the Air Force Civil Engineer Center (AFCEC) requests a Letter of Authorization (LOA) for the incidental taking, but not intentional taking (in the form of acoustic-related and/or pressure-related impacts), of marine mammals incidental to air-to-surface missions conducted in the Barking Sands Underwater Range Extension (BSURE) area of the Pacific Missile Range Facility (PMRF), as permitted by the Marine Mammal Protection Act (MMPA) of 1972, as amended. Air-to-surface missions consist of the activities described in the Preferred Alternative of the *Environmental Assessment/Overseas Environmental Assessment (EA/OEA) for the Long Range Strike Weapon Systems Evaluation Program* (WSEP), and presented in Section 1 of this document. The purpose of the Proposed Action is to authorize the Air Force to conduct operational evaluations of Long Range Strike weapons and other munitions as part of Long Range Strike WSEP operations. The need for the Proposed Action is to properly train units to execute requirements within Designed Operational Capability Statements, which describe units' real-world operational expectations in a time of war.

The missions may expose marine mammals in the BSURE area to sound exposure levels associated with Level A harassment and Level B harassment. No mortality is expected. Sound and pressure metrics associated with exploding ordnance were determined to be the only activities with potential for significant impacts to marine species, as analyzed in the associated EA/OEA. Long Range Strike WSEP missions involve the use of multiple types of live and inert munitions (bombs and missiles) scored at the water surface in the BSURE. The ordnance may be delivered by multiple types of aircraft, including bombers and fighter aircraft. Weapon performance will be evaluated by an underwater acoustic hydrophone array system as the weapons strike the water surface. Net explosive weight of the live munitions ranges from 23 to 300 pounds and all detonations will occur at the water surface. Missions will occur during summer 2016. All missions will be conducted during daylight hours. The Long Range Strike WSEP impact area is approximately 44 nautical miles (81 kilometers) offshore of Kauai, Hawaii, in a water depth of about 15,240 feet (4,645 meters).

The potential takes outlined in Section 6 represent the maximum expected number of animals that could be affected. Mitigation measures will be employed to decrease the number of animals potentially affected, particularly within the Level A harassment zone. Using the most applicable density estimates for each species, the zone of influence for each detonation event, and the total yearly number of planned events, an estimate of the potential number of animals exposed to acoustic and/or pressure thresholds was analyzed using the most recent criteria and thresholds (Finneran and Jenkins, 2012). Without mitigation measures in place, the total number of marine mammals potentially exposed to injurious (permanent threshold shift) Level A harassment is approximately 35 animals. A maximum of approximately 757 animals could potentially be exposed to non-injurious (temporary threshold shift) Level B harassment. Approximately 603 animals could potentially be exposed to noise corresponding to the Level B behavioral harassment threshold. It is anticipated that mitigation measures, identified in Section 11, will reduce the probability of all forms of take.

Marine mammals potentially affected by air-to-surface activities in the BSURE area include a total of 25 species and 27 stocks of whales, dolphins, and the Hawaiian monk seal (*Neomonachus schauinslandi*).

The information and analyses provided in this application are presented to fulfill the permit request requirements of Title I, Sections 101(a)(5)(A) and 101(a)(5)(F) of the MMPA.

This page is intentionally blank.

Request for an LOA for the Incidental Taking of Marine Mammals Resulting from Long Range Strike WSEP at the Pacific Missile Range Facility at Kauai, Hawaii

1.0 DESCRIPTION OF ACTIVITIES

1.1 INTRODUCTION

Due to threats to national security, increased missions involving air-to-surface activities have been directed by the Department of Defense (DoD). Accordingly, the U.S. Air Force (Air Force) seeks the ability to conduct operational evaluations of all phases of Long Range Strike weapons and other munitions within the U.S. Navy's Hawaii Range Complex (HRC). The actions would fulfill the Air Force's requirement to evaluate full-scale maneuvers for such weapons, including scoring capabilities, under operationally realistic scenarios.

In this document, air-to-surface activities refer to the deployment of missiles and bombs from aircraft to the water surface. Depending on the requirements of a given mission, munitions may be inert (containing no explosives or only a "spotting" charge) or live (contain explosive charges). Live munitions may detonate above, at, or slightly below the water surface. The Air Force is preparing an Environmental Assessment/Overseas Environmental Assessment (EA/OEA) to evaluate all components of the proposed activities. The activities described below in Section 1.2, *Mission Description*, represent the preferred alternative of the EA/OEA.

The activities will take place in the Barking Sands Underwater Range Extension (BSURE) area of the Pacific Missile Range Facility (PMRF), offshore of Kauai, Hawaii. Missions are planned to begin in summer 2016 and continue for the following five years. However, the 2016 missions involve only a small number of munitions that have been identified as an immediate need and which will all be tested on the same mission day. Therefore, activities occurring in 2016 have been addressed in a separate request for an Incidental Harassment Authorization (IHA). This Letter of Authorization (LOA) request includes only activities occurring from 2017 to 2021.

The 86th Fighter Weapons Squadron (86 FWS) is the test execution organization under the 53rd Wing for all Weapon Systems Evaluation Program (WSEP) deployments. WSEP objectives are to evaluate air-to-surface and maritime weapon employment data, evaluate tactics, techniques, and procedures in an operationally realistic environment and to determine the impact of tactics, techniques, and procedures on combat Air Force training. The munitions associated with the proposed activities are not part of a typical unit's training allocations, and prior to attending a WSEP evaluation, most pilots and weapon systems officers have only dropped weapons in simulators or used the aircraft's simulation mode. Without WSEP operations, pilots would be using these weapons for the first time in combat. On average, half of the participants in each unit drop an actual weapon for the first time during a WSEP evaluation. Consequently, WSEP is a military readiness activity and is the last opportunity for squadrons to receive operational training and evaluation before they deploy.

This document has been prepared in accordance with the applicable regulations of the Marine Mammal Protection Act of 1972 (MMPA), as amended by the National Defense Authorization Act for Fiscal Year 2004 (Public Law 108-136) and its implementing regulations. The LOA request is based on: (1) the analysis of spatial and temporal distributions of marine mammals in the BSURE area (also referred to as the Study Area), (2) the review of testing activities that have the potential to incidentally take marine mammals, and (3) a technical risk assessment to determine the likelihood of effects. This chapter describes those activities that are likely to result in Level B harassment or Level A harassment under the MMPA.

1.2 MISSION DESCRIPTION

This section describes the Long Range Strike WSEP missions to be conducted by the Air Force in the BSURE area of the PMRF (see Section 2, *Duration and Location of the Activities*, for a description of the

Study Area). The actions include air-to-surface test missions of the Joint Air-to-Surface Stand-off Missile/Joint Air-to-Surface Stand-off Missile-Extended Range (JASSM/JASSM-ER), Small Diameter Bomb-I/II (SDB-I/II), High-speed Anti-Radiation Missile (HARM), Joint Direct Attack Munition/Laser Joint Direct Attack Munition (JDAM/LJDAM), and Miniature Air-Launched Decoy (MALD), including detonations above the water, at the water surface, and slightly below the water surface. The following subsections describe aircraft operations, weapons used, schedule, and typical mission procedures.

Aircraft Operations

Aircraft used for munition releases would include bombers and fighter aircraft. Additional airborne assets, such as the P-3 Orion or the P-8 Poseidon, would be used to relay telemetry (TM) and flight termination system (FTS) streams between the weapon and ground stations. Other support aircraft would be associated with range clearance activities before and during the mission and with air-to-air refueling operations. All weapon delivery aircraft would originate from an out base and fly into military-controlled airspace prior to employment. Due to long transit times between the out base and mission location, air-to-air refueling may be conducted in either Warning Area 188 (W-188) or W-189. Bombers, such as the B-1, would deliver the weapons, conduct air-to-air refueling, and return to their originating base as part of one sortie. However, when fighter aircraft are used, the distance and corresponding transit time to the various potential originating bases would make return flights after each mission day impractical. In these cases, the aircraft would temporarily (less than one week) park overnight at Hickam Air Force Base (AFB) and would return to their home base at the conclusion of each mission set. Multiple weapon-release aircraft would be used during some missions, each potentially releasing multiple munitions. Each Long Range Strike WSEP mission set will occur over a maximum of five consecutive days per year. Approximately 10 Air Force personnel would be on temporary duty to support each mission set. Table 1-1 summarizes example types of aircraft proposed to support Long Range Strike WSEP missions.

Table 1-1. Summary of Example Aircraft Usage During Long Range Strike WSEP Missions

Type	Example Aircraft	Purpose	Potential Outbases
Bombers	B-1, B-2, B-52	Weapon release	Ellsworth AFB; Dyess AFB; Barksdale AFB; Whiteman AFB; Minot AFB
Fighter aircraft	F-15, F-16, F-22, F-35	Weapon release, chase aircraft, range clearance	Mountain Home AFB; Nellis AFB; Hill AFB; JB Hickam-Pearl Harbor; JB Elmendorf-Richardson; JB Langley-Eustis
Refueling tankers	KC-135	Air-to-air refueling	McConnell AFB
Surveillance	P-3, P-8	TM and FTS relays	NAS Point Mugu
Helicopters	S-61N	Range clearance, protected species surveys	PMRF
Cargo aircraft	C-130, C-26	Range clearance, protected species surveys	U.S. Coast Guard; PMRF

AFB = Air Force Base; FTS = flight termination system; JB = Joint Base; NAS = Naval Air Station; PMRF = Pacific Missile Range Facility; TM = telemetry

Aircraft flight maneuver operations and weapon release would be conducted in W-188A. Chase aircraft may be used to evaluate weapon release and to track weapons. Flight operations and weapons delivery would be in accordance with published Air Force directives and weapon operational release parameters, as well as all applicable Navy safety regulations and criteria established specifically for PMRF. Aircraft supporting Long Range Strike WSEP missions would primarily operate at high altitudes, only flying below 3,000 feet for a limited time as needed for escorting non-military vessels outside the hazard area or for monitoring the area for protected marine species (e.g., marine mammals, sea turtles). Protected marine species aerial surveys would be temporary and would focus on an area surrounding the weapon impact point on the water. Post-mission surveys would focus on the area down current of the weapon impact location. A detailed description of protected marine species clearance procedures is included in Section 11. Range clearance procedures for each mission would cover a much larger area for human safety. Weapon release parameters would be conducted as approved by PMRF Range Safety. Daily mission briefs would specify planned release conditions for each mission. Aircraft and weapons would be tracked for time, space, and position information. The 86 FWS test director would coordinate with the PMRF Range Safety Officer, Operations Conductor, Range Facility Control Officer, and other applicable mission control personnel for aircraft control, range clearance, and mission safety. Figure 1-1 shows a photograph taken from a chase aircraft of a JASSM being released and in flight.

Figure 1-1. Joint Air-to-Surface Stand-Off Missile (JASSM) Released

Weapons Descriptions

Joint Air-to-Surface Stand-off Missile/Joint Air-to-Surface Stand-Off Missile-Extended Range (JASSM/JASSM-ER)

The JASSM (Figure 1-2) is a stealthy precision cruise missile designed for launch outside area defenses against hardened, medium-hardened, soft, and area type targets. The JASSM has a range of more than 200 nautical miles (NM) (370 kilometers [km]) and carries a 1,000-pound warhead with approximately 300 pounds of 2,4,6-trinitrotoluene (TNT) equivalent net explosive weight (NEW). The specific explosive used is AFX-757, a type of plastic bonded explosive (PBX). The weapon has the capability to fly a preprogrammed route from launch to a target, using Global Positioning System (GPS) technology and an internal navigation system (INS) combined with a Terminal Area Model when available. Additionally, the weapon has a Common Low Observable Auto-Routing function that gives the weapon the ability to find the route that best utilizes the low observable qualities of the JASSM. In either case, these routes can be modeled prior to weapon release. The JASSM-ER has additional fuel and a different engine for a greater range than the JASSM (500 NM [926 km]) but maintains the same functionality of the JASSM.

Figure 1-2. Joint Air-to-Surface Stand-Off Missile (JASSM)

Small Diameter Bomb-I/Small Diameter Bomb-II (SDB-I/SDB-II)

The SDB I (Figure 1-3) is a 250-pound air-launched GPS-INS guided weapon for fixed soft to hardened targets. SDB II (Figure 1-4) expands the SDB I capability with network enabling and uses a tri-mode sensor infrared, millimeter, and semi-active laser to attack both fixed and movable targets. Both munitions have a range of up to 60 NM (111 km). The SDB-I contains 37 pounds of TNT-equivalent NEW, and the SDB-II contains 23 pounds NEW. The explosive used in both SDB-I and SDB-II is AFX-757.

Figure 1-3. Small Diameter Bomb-I (SDB-I)

Figure 1-4. Small Diameter Bomb-II (SDB-II)

High-speed Anti-Radiation Missile (HARM)

The HARM (Figure 1-5) is a supersonic air-to-surface missile designed to seek and destroy enemy radar-equipped air defense systems. The HARM has a proportional guidance system that homes in on enemy radar emissions through fixed antenna and seeker head in the missile nose. It has a range of up to 80 NM (148 km) and contains 45 pounds of TNT-equivalent NEW. The explosive used is PBXN-107.

Figure 1-5. High-speed Anti-Radiation Missile (HARM)

Joint Direct Attack Munition/Laser Joint Direct Attack Munition (JDAM/LJDAM)

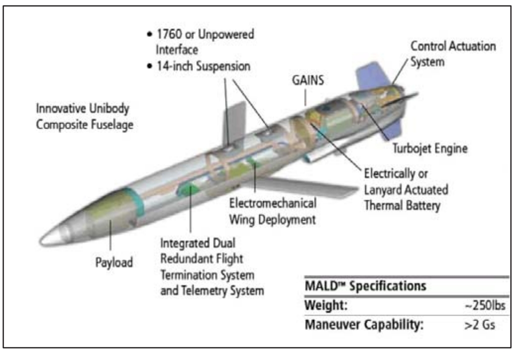
The JDAM (Figure 1-6) is a smart GPS-INS weapon that uses an unguided gravity bomb and adds a guidance and control kit, converting it to a precision-guided munition. The LJDAM variant adds a laser sensor to the JDAM, permitting guidance to a laser designated target. Both JDAM and LJDAM contain 192 pounds of TNT-equivalent NEW with multiple fusing options, with detonations occurring upon impact or with up to a 10-millisecond delay.

Figure 1-6. Joint Direct Attack Munition (JDAM)

Miniature Air Launched Decoy/Miniature Air Launched Decoy-Jamming (MALD/MALD-J)

The MALD (Figure 1-7) is an air-launched, expendable decoy that will provide the Air Force the capability to simulate, deceive, decoy, and saturate an enemy's threat integrated air defense system (IADS). The MALD production has recently transitioned to include the MALD-J variant, which has the same decoy capability of the MALD plus the addition of jamming IADS. The MALD and MALD-J have ranges up to 500 NM (926 km) to include a 200-NM (370-km) dash with a 30-minute loiter mode. It has no warhead and, therefore, no detonation upon impact with the water surface would occur.

Figure 1-7. Miniature Air Launched Decoy (MALD/MALD-J)



Schedule and General Mission Procedures

The initial phase of the Long Range Strike WSEP operational evaluations is scheduled for September 2016 and will consist of releasing only one live JASSM/JASSM-ER and eight SDBs. Immediate evaluations for JASSM/JASSM-ER and SDB I are needed; therefore, they are the only munitions being proposed for 2016 missions. Weapon release parameters for 2016 mission would involve a B-1 bomber releasing one live JASSM and fighter aircraft, such as F-15, F-16, or F-22, releasing live SDB-I. Up to four SDB-I munitions would be released simultaneously, similar to a ripple effect, each hitting the water surface within a few seconds of each other as a burst; however, the SDB-I releases would occur separately from the JASSM. All releases would occur on the same mission day. As described in Section 1.1, these activities have been addressed in a separate IHA request. This LOA request includes only activities in follow-on years occurring from 2017 to 2021.

Missions conducted in 2017 to 2021 would add deployments of live and inert HARM, JDAM/LJDAM, and MALD/MALD-J munitions, in addition to continued evaluation of JASSM/JASSM-ER and SDB I/II. Releases of live ordnance associated with 2017 – 2021 missions would result in either airbursts, surface detonations, or subsurface detonations (10-foot [3-meter] water depth). Similar to 2016 missions, up to four SDB I/II munitions could be released simultaneously, such that each ordnance would hit the water surface within a few seconds of each other. Aside from the SDB-I/II releases, all other weapons would be released separately, impacting the water surface at different times. There will be a total of five mission days per year during the time frame of 2017 to 2021.

A typical mission day would consist of pre-mission checks, safety review, crew briefings, weather checks, clearing airspace, range clearance, mitigations/monitoring efforts, and other military protocols prior to launch of weapons. Potential delays could be the result of multiple factors including, but not limited to, adverse weather conditions leading to unsafe take-off, landing, and aircraft operations, inability to clear the range of non-mission vessels or aircraft, mechanical issues with mission aircraft or munitions, or presence of protected species in the impact area. These standard operating procedures are usually done in the morning, and live range time may begin in late morning once all checks are complete and approval is granted from range control. The range would be closed to the public for a maximum of four hours per mission day.

Each long range strike weapon would be released in W-188A and would follow a given flight path with programmed GPS waypoints to mark its course in the air. Long range strike weapons would complete their maximum flight range (up to 500-NM distance for JASSM-ER) at an altitude of approximately 18,000 feet mean sea level (MSL) and terminate at a specified location for scoring of the impact. The cruise time would vary among the munitions, but would be about 45 minutes for JASSM/JASSM-ER and 10 minutes for SDB-I/II. The time frame between employments of successive munitions would vary, but releases could be spaced by approximately one hour to account for the JASSM cruise time. The routes and associated safety profiles would be contained within W-188A boundaries. The objective of the route designs is to complete full-scale evasive maneuvers that avoid simulated threats and would, therefore, not consist of a standard "paper clip" or regularly shaped route. The final impact point on the water surface would be programmed into the munitions for weapons scoring and evaluations. The JDAM/LJDAM munitions would also be set to impact at the same point on the water surface.

All missions would be conducted in accordance with applicable flight safety, hazard area, and launch parameter requirements established for PMRF. A weapon hazard region would be established, with the size and shape determined by the maximum distance that a weapon could travel in any direction during its descent. The hazard area is typically adjusted for potential wind speed and direction, resulting in a maximum composite safety footprint for each mission (each footprint boundary is at least 10 NM from the Kauai coastline). This information is used to establish a Launch Exclusion Area and Aircraft Hazard Area. These exclusion areas must be verified to be clear of all non-mission and non-essential vessels and aircraft before live weapons are released. In addition, a buffer area must also be clear on the water surface so that vessels do not enter the exclusion area during the launch window. Prior to weapon release, a range sweep of the hazard area would be conducted by participating mission aircraft or other appropriate aircraft, potentially including S-61N helicopter, C-26 aircraft, fighter aircraft (F-15E, F-16, F-22), or the Coast Guard's C-130 aircraft.

PMRF has used small water craft docked at the Port Allen public pier to keep nearshore areas clear of tour boats for some mission launch areas. However, for missions with large hazard areas that occur far offshore from Kauai, it would be impractical for these smaller vessels to conduct range clearance activities. The composite safety footprint weapons associated with Long Range Strike WSEP missions is anticipated to be rather large; therefore, it is likely that range clearing activities would be conducted solely by aircraft.

The Range Facility Control Officer is responsible for establishing hazard clearance areas, directing clearance and surveillance assets, and reporting range status to the Operations Conductor. The Control Officer is also responsible for submitting all Notice to Airmen (NOTAMs) and Notice to Mariners (NOTMARs), and for requesting all Federal Aviation Administration airspace clearances. In addition to the human safety measures described above, protected species surveys are carried out before and after missions, as summarized in Section 11.

Table 1-2 summarizes munition and mission information for activities scheduled to occur annually at PMRF from 2017 through 2021.

Table 1-2. Summary of Proposed Testing at Pacific Missile Range Facility from 2017 to 2021

Type of Munition	Live or Inert	NEW (lb)	Type of Aircraft	Detonation Scenario	Number of Proposed Releases				
					2017	2018	2019	2020	2021
JASSM/ JASSM-ER	Live	300	Bomber, Fighter	Surface	6	6	6	6	6
SDB-I	Live	37	Bomber, Fighter	Surface	30	30	30	30	30
SDB-II	Live	23	Bomber, Fighter	Surface	30	30	30	30	30
HARM	Live	45	Fighter	Surface	10	10	10	10	10
JDAM/LJDAM	Live	192	Bomber, Fighter	Subsurface[1]	30	30	30	30	30
MALD/ MALD-J	Inert	N/A	Fighter	N/A	4	4	4	4	4

HARM = High Anti-Radiation Missile; JASSM = Joint Air-to-Surface Standoff Missile; JASSM-ER = Joint Air-to-Surface Standoff Missile – Extended Range; JDAM = Joint Direct Attack Munition; lb = pounds; LJDAM = Laser Joint Direct Attack Munition; MALD = Miniature Air Launched Decoy; MALD-J = Miniature Air Launched Decoy – Jamming; N/A = not applicable (inert); SDB = Small Diameter Bomb

1. Assumes a 10-millisecond time-delayed fuse resulting in detonation occurring at an approximate 10-foot water depth.

This page is intentionally blank.

2.0 DURATION AND LOCATION OF THE ACTIVITIES

Long Range Strike WSEP missions will occur on weekdays, during daytime hours only. All activities will take place within the PMRF, which is located in Hawaii on and off the western shores of the island of Kauai and includes broad ocean areas to the north, south, and west (Figure 2-1). However, there would be no ground-based or nearshore activities requiring the use of any shoreline areas of Kauai; all aspects and associated impacts from Long Range Strike WSEP missions would occur over open ocean areas. PMRF, as part of the Navy's HRC, is a Major Range and Test Facility Base and, as such, supports the full spectrum of DoD test and evaluation requirements. PMRF is also the world's largest instrumented, multi-environment military testing and training range capable of supporting subsurface, surface, air, and space operations. The PMRF includes 1,020 square nautical miles (NM^2) of instrumented ocean areas at depths between 1,800 feet (549 meters [m]) and 15,000 feet (4,572 m), 42,000 NM^2 of controlled airspace, and a temporary operating area covering 2.1 million NM^2 of ocean area.

Within the PMRF, activities would occur in the BSURE area, which lies in W-188A. The specific impact location within the BSURE area, which is the central point around which all missions are expected to occur, is shown on Figure 2-2. The BSURE consists of about 900 NM^2 of instrumented underwater ranges, encompassing the deepwater portion of the PMRF and providing over 80 percent of PMRF's underwater scoring capability. The BSURE facilitates training, tactics, development, and test and evaluation for air, surface, and subsurface weapons systems in deep water. It provides a full spectrum of range support, including radar, underwater instrumentation, telemetry, electronic warfare, remote target command and control, communications, data display and processing, and target/weapon launching and recovery facilities. The underwater tracking system begins 9 NM (17 km) from the north shore of Kauai and extends out to 40 NM (74 km) from shore. Long Range Strike WSEP missions would employ live weapons with long flight paths requiring large amounts of airspace and conclude with weapon impact and surface detonations within the BSURE instrumented range.

Figure 2-1. Regional Location of Long Range Strike WSEP Activities

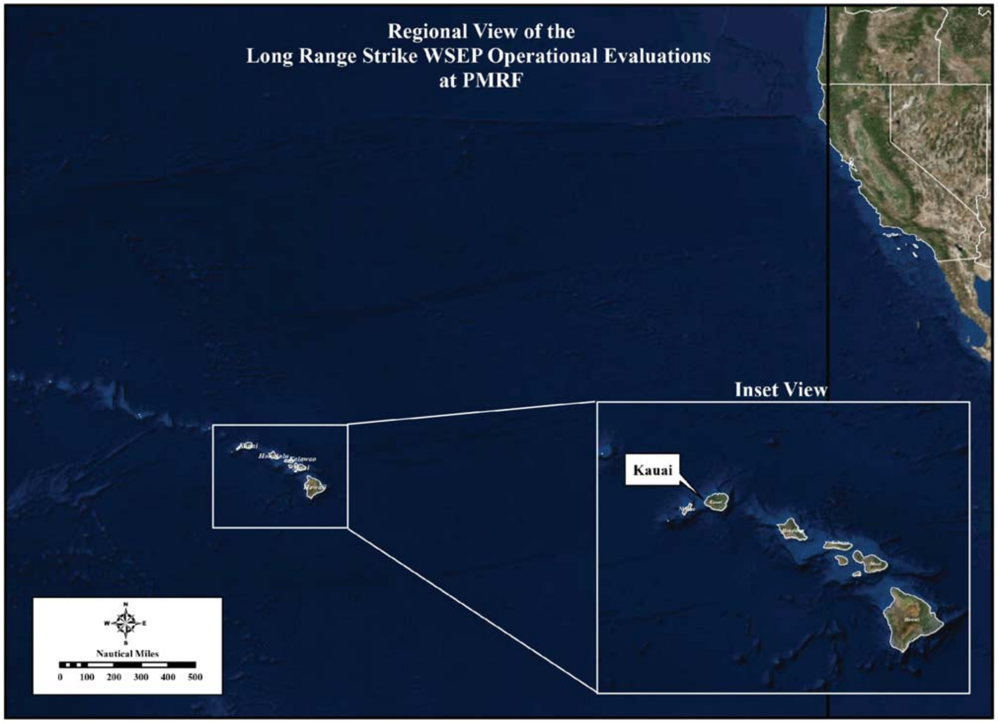
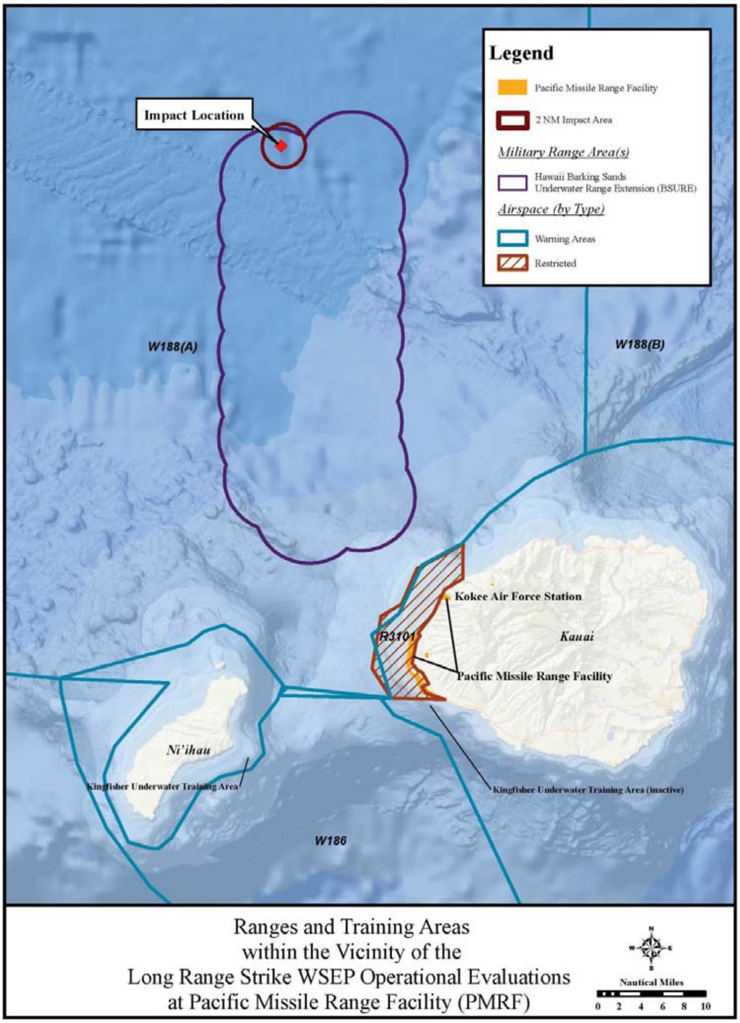


Figure 2-2. Pacific Missile Range Facility on Kauai, Hawaii



This page is intentionally blank.

3.0 MARINE MAMMAL SPECIES AND NUMBERS

This section identifies marine mammal species and stocks potentially found in the PMRF (including the BSURE area), provides general information on marine mammal behavior, hearing and vocalization, and threats, and provides a density estimate for each species. Marine mammals are a diverse group of approximately 130 species that rely wholly or substantially on the sea for important life functions and include cetaceans (whales, dolphins, and porpoises), pinnipeds (seals, sea lions, and walruses), sirenians (manatees, dugongs, and sea cows), marine otters, and polar bears. Of these animal groups, whales, dolphins, and one pinniped occur in the Study Area. Although most marine mammal species live wholly or predominantly in the marine habitat, some spend time in terrestrial habitats (e.g., seals) or freshwater environments (e.g., freshwater dolphins). All marine mammals in the United States are protected under the MMPA; some species are additionally protected under the Endangered Species Act of 1973 (ESA). Marine mammals may be designated under the ESA as endangered, threatened, candidate, or proposed species. Under the MMPA, species may be designated as depleted, which is defined as a species or stock that is (1) below its optimum sustainable population or (2) designated as endangered or threatened under the ESA. Marine mammal species protected under the ESA are evaluated separately in an associated Biological Assessment.

Cetaceans may be categorized as odontocetes or mysticetes. Odontocetes, which range in size from about 1 m to over 18 m, have teeth that are used to capture and consume individual prey. Mysticetes, which are also known as baleen whales, range in size from about 10 m to over 30 m. Instead of teeth, mysticetes have baleen (a fibrous structure made of keratin) in their mouth, which is used to filter the large numbers of small prey that are engulfed, sucked, or skimmed from the water or ocean floor sediments. Cetaceans inhabit virtually every marine environment, from coastal waters to the open ocean. Their distribution is primarily influenced by prey availability, which depends on factors such as ocean current patterns, bottom relief, and sea surface temperature, among others. Most of the large cetaceans are migratory, but many small cetaceans do not migrate in the strictest sense. Instead, they may undergo seasonal dispersal, or shifts in density. Pinnipeds generally spend a large portion of time on land at haulout sites used for resting and moulting, and at rookeries used for breeding and nursing young, and return to the water to forage. The only pinniped species that occurs regularly in Hawaii is the Hawaiian monk seal (*Neomonachus schauinslandi*). In the Main Hawaiian Islands, they are generally solitary and have no established rookeries.

Marine mammals with potential occurrence in the BSURE area are shown in Table 3-1.

Table 3-1. Marine Mammals with Potential Occurrence in the Study Area

Common Name	Scientific Name
Mysticetes (baleen whales)	
Humpback whale	*Megaptera novaeangliae*
Blue whale	*Balaenoptera musculus*
Fin whale	*Balaenoptera physalus*
Sei whale	*Balaenoptera borealis*
Bryde's whale	*Balaenoptera brydei/edeni*
Minke whale	*Balaenoptera acutorostrata*
Odontocetes (toothed whales and dolphins)	
Sperm whale	*Physeter macrocephalus*
Pygmy sperm whale	*Kogia breviceps*
Dwarf sperm whale	*Kogia sima*
Killer whale	*Orcinus orca*
False killer whale	*Pseudorca crassidens*
Pygmy killer whale	*Feresa attenuata*

Table 3-1. Marine Mammals with Potential Occurrence in the Study Area, Cont'd

Common Name	Scientific Name
Short-finned pilot whale	*Globicephala macrorhynchus*
Melon-headed whale	*Peponocephala electra*
Bottlenose dolphin	*Tursiops truncatus*
Pantropical spotted dolphin	*Stenella attenuata*
Striped dolphin	*Stenella coeruleoalba*
Spinner dolphin	*Stenella longirostris*
Rough-toothed dolphin	*Steno bredanensis*
Fraser's dolphin	*Lagenodelphis hosei*
Risso's dolphin	*Grampus griseus*
Cuvier's beaked whale	*Ziphius cavirostris*
Blainville's beaked whale	*Mesoplodon densirostris*
Longman's beaked whale	*Indopacetus pacificus*
Pinnipeds	
Hawaiian monk seal	*Neomonachus schauinslandi*

General Behavior

Many species of marine mammals, particularly odontocetes, are highly social animals that spend much of their lives living in groups or schools ranging from several individuals to several thousand individuals. Aggregations of baleen whales may form during particular breeding or foraging seasons, although they do not appear to persist over time as a social unit. All marine mammals dive beneath the water surface, primarily for the purpose of foraging. Dive frequency and the time spent during dives vary among species and within individuals of the same species. Some species that forage on deep-water prey can make dives lasting over an hour. Other species spend the majority of their lives close to the surface and make relatively shallow dives. The diving behavior of a particular species or individual has implications regarding the ability to detect them during mitigation and monitoring activities. In addition, their distribution through the water column is an important consideration when conducting acoustic exposure analyses.

Vocalization and Hearing

All marine mammals that have been studied can produce sounds and use sounds to forage, orient, detect and respond to predators, and socially interact with others. Measurements of marine mammal sound production and hearing capabilities provide some basis for assessment of whether exposure to a particular sound source may affect a marine mammal. Marine mammal hearing abilities are quantified using live animals either via behavioral audiometry or electrophysiology. Behavioral audiograms are plots of animals' exhibited hearing threshold versus frequency, and are obtained from captive, trained live animals. Behavioral audiograms are difficult to obtain because many species are too large, too rare, and too difficult to acquire and maintain for experiments in captivity. Electrophysiological audiometry measures small electrical voltages produced by neural activity when the auditory system is stimulated by sound. The technique is relatively fast, does not require a conscious response, and is routinely used to assess the hearing of newborn humans. Understanding of a species' hearing ability may be based on the behavioral audiogram of only a single individual or small group of animals. In addition, captive animals may be exposed to local ambient sounds and other environmental factors that may impact their hearing abilities and may not accurately reflect the hearing abilities of free-swimming animals (Houser, Finneran, et al., 2010). For animals not available in captive or stranded settings (including large whales and rare species), estimates of hearing capabilities are made based on physiological structures, vocal characteristics, and extrapolations from related species.

Direct measurement of hearing sensitivity exists for only about 25 of the nearly 130 species of marine mammals. Table 3-2 provides a summary of sound production and general hearing capabilities for marine mammals with potential occurrence in the Study Area. For purposes of the analyses in this document, marine mammals are arranged into the following functional hearing groups based on their generalized hearing sensitivities: high-frequency cetaceans, mid-frequency cetaceans, low-frequency cetaceans (mysticetes), and phocid pinnipeds (true seals). Summaries of the functional hearing groups applicable to this document are provided below. For a detailed discussion of all marine mammal functional hearing groups and their derivation, see Finneran and Jenkins (2012).

Table 3-2. Hearing and Vocalization Ranges for Marine Mammal Functional Hearing Groups and Species Potentially Occurring within the Study Area

Functional Hearing Group	Species Potentially Present in the Study Area	Sound Production		General Hearing Ability Frequency Range
		Frequency Range	Source Level (dB re 1 µPa @ 1 m)	
High-Frequency Cetaceans	Kogia Species (Dwarf Sperm Whale and Pygmy Sperm Whale)	100 Hz to 200 kHz	120 to 205	200 Hz to 180 kHz
Mid-Frequency Cetaceans	Sperm Whale, Beaked Whales (*Indopacetus*, *Mesoplodon*, and *Ziphius* species), Bottlenose Dolphin, Fraser's Dolphin, Killer Whale, False Killer Whale, Pygmy Killer Whale, Melon-headed Whale, Short-finned Pilot Whale, Risso's Dolphin, Rough-toothed Dolphin, Spinner Dolphin, Pantropical Spotted Dolphin, Striped Dolphin	100 Hz to >100kHz	118 to 236	150 Hz to 160 kHz
Low-Frequency Cetaceans	Blue Whale, Bryde's Whale, Fin Whale, Humpback Whale, Minke Whale, Sei Whale	10 Hz to 20 kHz	129 to 195	7 Hz to 22 kHz
Phocidae	Hawaiian monk seal	100 Hz to 12 kHz	103 to 180	In water: 75 Hz to 75 kHz

> = greater than; dB re 1 µPa @ 1 m = decibels referenced to 1 microPascal at 1 meter; Hz = hertz; kHz = kilohertz

High-Frequency Cetaceans. Marine mammals within the high-frequency cetacean functional hearing group are all odontocetes (toothed whales) and includes eight species and subspecies of porpoises (family: Phocoenidae); dwarf and pygmy sperm whales (family: Kogiidae); six species and subspecies of river dolphins; and four species of Cephalorhynchus. The only high-frequency cetaceans found in the Study Area are dwarf sperm whale and pygmy sperm whale. Functional hearing in high-frequency cetaceans occurs between approximately 200 hertz (Hz) and 180 kilohertz (kHz) (Southall et al., 2007).

Sounds produced by high-frequency cetaceans range from approximately 100 Hz to 200 kHz with source levels of 120 to 205 decibels (dB) referenced to (re) 1 micro (µ) Pascal (Pa) at 1 m (Madsen et al., 2005; Richardson et al., 1995; Verboom and Kastelein, 2003; Villadsgaard et al., 2007). Recordings of sounds produced by dwarf and pygmy sperm whales consist almost entirely of the click/pulse type (Marten, 2000). High-frequency cetaceans also generate specialized clicks used in biosonar (echolocation) at frequencies above 100 kHz that are used to detect, localize, and characterize underwater objects such as prey (Richardson et al., 1995).

An electrophysiological audiometry measurement on a stranded pygmy sperm whale indicated best sensitivity between 90 to 150 kHz (Ridgway and Carder, 2001).

Mid-Frequency Cetaceans. Marine mammals within the mid-frequency cetacean functional hearing group are all odontocetes, and include the sperm whale (family: Phystereidae); 32 species and subspecies of dolphins (family: Delpinidae); the beluga and narwhal (family: Monodontidae); and 19 species of beaked and bottlenose whales (family: Ziphiidae). The following members of the mid-frequency cetacean group are present or have a reasonable likelihood of being present in the Study Area: sperm whale, killer whale, false killer whale, pygmy killer whale, short-finned pilot whale, melon-headed whale, common bottlenose dolphin, pantropical spotted dolphin, striped dolphin, spinner dolphin, rough-toothed dolphin, Fraser's dolphin, Risso's dolphin, and beaked whales (*Berardius, Indopacetus, Mesoplodon*, and *Ziphius* species). Functional hearing in mid-frequency cetaceans is conservatively estimated to be between approximately 150 Hz and 160 kHz (Southall et al., 2007).

Hearing studies on cetaceans have focused primarily on odontocete species, and hearing sensitivity has been directly measured for a number of mid-frequency cetaceans, including Atlantic white-sided dolphins (*Lagenorhynchus acutus*) (Houser, Dankiewicz-Talmadge, et al., 2010), common dolphins (*Delphinus* spp.) (Houser, Dankiewicz-Talmadge, et al., 2010), Atlantic bottlenose dolphins (Johnson, 1967), belugas (White et al., 1977; Finneran et al., 2005), Indo-Pacific bottlenose dolphins (Houser, Dankiewicz-Talmadge, et al., 2010), Black Sea bottlenose dolphins (Popov et al., 2007), striped dolphins (Kastelein et al., 2003), white-beaked dolphins (Nachtigall et al., 2008), Risso's dolphins (Nachtigall et al., 2005), belugas (*Delphinapterus leucas*) (Finneran et al., 2005; White et al., 1977), false killer whales (Yuen et al., 2005), killer whales (Szymanski et al., 1999), Gervais' beaked whales (Finneran and Schlundt, 2009), and Blainville's beaked whales (Pacini et al., 2011). All audiograms exhibit the same general U-shape, with a wide nominal hearing range between approximately 150 Hz and 160 kHz.

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

Low-Frequency Cetaceans. Marine mammals within the low-frequency functional hearing group are all mysticetes. This group is comprised of 13 species and subspecies of mysticete whales in six genera: *Eubalaena, Balaena, Caperea*, *Eschrichtius, Megaptera*, and *Balaenoptera*. The following members of the low-frequency cetacean group are present or have a reasonable likelihood of being present in the Study Area: humpback, blue, fin, sei, Bryde's, and minke whales. Functional hearing in low-frequency cetaceans is conservatively estimated to be between approximately 7 Hz and 22 kHz (Southall et al., 2007).

Because of animal size and availability of live specimens, direct measurements of mysticete whale hearing are unavailable, although there was one effort to measure hearing thresholds in a stranded grey whale (Ridgway and Carder, 2001). Because hearing ability has not been directly measured in these species, it is inferred from vocalizations, ear structure, and field observations. Vocalizations are audible somewhere in the frequency range of production, but the exact range cannot be inferred (Southall et al., 2007).

Mysticete cetaceans produce low-frequency sounds that range in the tens of Hz to several kHz that most likely serve social functions such as reproduction, but may have an orientation function as well (Green et al., 1994). Humpback whales are the notable exception within the mysticetes, with some calls exceeding 10 kHz. These sounds can be generally categorized as low-frequency moans; bursts or pulses; or more complex songs (Edds-Walton, 1997; Ketten, 1997). Source levels of most mysticete sounds range from 150–190 dB re 1 μPa (see Richardson et al., 1995).

Phocid Pinnepeds. The only phocid (true seal) present in the Study Area is the Hawaiian monk seal. Hearing in phocids has been tested in the following species: gray seals (Ridgway et al., 1975); harbor seals (Richardson et al., 1995; Terhune and Turnbull, 1995; Kastak and Schusterman, 1998; Wolski et al., 2003; Southall et al., 2007; Kastelein et al., 2012); harp seals (Terhune and Ronald, 1971; Terhune and Ronald, 1972); Hawaiian monk seals (Thomas et al., 1990); northern elephant seal (Kastak and Schusterman, 1998; Kastak and Schusterman, 1999); and ringed seals (Terhune and Ronald, 1975; Terhune and Ronald, 1976). Phocid hearing limits are estimated to be 75 Hz–30 kHz in air and 75 Hz–75 kHz in water (Kastak and Schusterman, 1999; Kastelein et al., 2009 Møhl, 1968; Reichmuth, 2008; Terhune and Ronald, 1971; Terhune and Ronald, 1972).

General Threats

Marine mammal populations can be influenced by various factors and human activities. These factors can affect marine mammal populations directly (e.g., hunting and whale watching), or indirectly (e.g., reduced prey availability or lowered reproductive success). Marine mammals may also be influenced by natural phenomena such as storms and other extreme weather patterns, and climate change. Generally, not much is known about how large storms and other weather patterns affect marine mammals, other than that mass strandings (when two or more marine mammals become beached or stuck in shallow water) sometimes coincide with hurricanes, typhoons, and other tropical storms (Marsh, 1989; Rosel and Watts, 2008). Climate change can potentially affect marine mammal species directly through habitat loss (especially for species that depend on ice or terrestrial areas) and indirectly via impacts on prey, changing prey distributions and locations, and changes in water temperature.

Mass die offs of some marine mammal species have been linked to toxic algal blooms. In such cases, the mammals consume prey that has consumed toxic plankton. All marine mammals have parasites that, under normal circumstances, probably do little overall harm, but that under certain conditions can cause health problems or even death (Jepson et al., 2005; Bull et al., 2006; Fauquier et al., 2009). Disease affects some individuals (especially older animals), and occasionally disease epidemics can injure or kill a large percentage of a population (Paniz-Mondolfi and Sander-Hoffmann, 2009; Keck et al., 2010). Recently the first case of morbillivirus in the central Pacific was documented for a stranded Longman's beaked whale at Maui (West et al., 2012).

Human impacts on marine mammals have received much attention in recent decades and include hunting (both commercial and native practices), fisheries interactions (such as gear entanglement or shootings by fishers), bycatch (accidental or incidental catch), indirect effects of fisheries through takes of prey species, ship strikes, noise pollution, chemical pollution, and general habitat deterioration or destruction. Direct hunting, as in whaling and sealing operations, provided the original impetus for marine mammal management efforts and has driven much of the early research on cetaceans and pinnipeds (Twiss and Reeves, 1999). In 1994, the MMPA was amended to formally address bycatch. Cetacean bycatch subsequently declined by 85 percent between 1994 and 2006. However, fishery bycatch is likely the most impactful problem presently and may account for the deaths of more marine mammals than any other cause (Northridge, 2008; Read, 2008; Hamer et al., 2010; Geijer and Read, 2013). For example, bycatch has significantly contributed to the decline of the Hawaiian population of false killer whales (Boggs et al., 2010).

Ship strikes are an issue of increasing concern for most marine mammals, particularly baleen whale species. There were nine reported ship collisions with humpback whales in the Hawaiian Islands in 2006 (none involved Navy vessels), as recorded by the National Marine Fisheries Service (NMFS) Pacific Islands Region Marine Mammal Response Network Activity Updates (NMFS, 2007a). Overall, from 2007 to 2012 in Hawaii, there were 39 vessel collisions involving humpback whales (Bradford and Lyman, 2015). None of these strikes involved Navy vessels. A humpback carcass was discovered on the shore of southwest Molokai in 2010 with indications that the death resulted from trauma consistent with a ship strike (NMFS, 2010a). Chemical pollution is also of concern, although for the most part, its effects on marine mammals are not well understood (Aguilar de Soto et al., 2008). Chemical pollutants found in pesticides flow into the marine environment from human use on land and are absorbed into the bodies of marine mammals, accumulating in their blubber or internal organs, or are transferred to the young from its mother's milk (Fair et al., 2010). Marine mammals that live closer to the source of pollutants and those that feed on higher-level organisms have increased potential to accumulate toxins (Moon et al., 2010). The buildup of human-made persistent compounds in marine mammals not only increases their likelihood of contracting diseases or developing tumors, but also compromises the function of their reproductive systems (Fair et al., 2010). Oil and other chemical spills are a specific type of ocean contamination that can have damaging effects on some marine mammal species (see Matkin et al., 2008).

Habitat deterioration and loss is a major factor for almost all coastal and inshore species of marine mammals, especially those that live in rivers or estuaries, and it may include such factors as depleting a habitat's prey base and the complete loss of habitat (Kemp, 1996; Smith et al., 2009; Ayres et al., 2012). In some locations, especially where urban or industrial activities or commercial shipping is intense, anthropogenic noise is also being increasingly considered as a potential habitat level stressor. Noise is of particular concern to marine mammals because many species use sound as a primary sense for navigating, finding prey, avoiding predators, and communicating with other individuals. Noise may cause marine mammals to leave a habitat, impair their ability to communicate, or cause stress (Hildebrand, 2009; Tyack et al., 2011; Rolland et al., 2012; Erbe et al., 2012). Noise can cause behavioral disturbances, mask other sounds (including their own vocalizations), may result in injury and in some cases, may result in behaviors that ultimately lead to death (National Research Council, 2003; National Research Council, 2005; Nowacek et al., 2007; Würsig and Richardson, 2009; Southall et al., 2009; Tyack, 2009a). Anthropogenic noise is generated from a variety of sources including commercial shipping, oil and gas activities, commercial and recreational fishing, recreational boating and whale watching, offshore power generation, research (including sound from air guns, sonar, and telemetry), and military training and testing activities. Vessel noise in particular is a large contributor to noise in the ocean. Commercial shipping's contribution to ambient noise in the ocean has increased by as much as 12 dB over the last few decades (McDonald et al., 2008; Hildebrand, 2009).

Marine mammals as a whole are subject to the various influences and factors described above. If additional specific threats to individual species within the Study Area are known, those threats are described in the species accounts in Section 4, *Affected Species Status and Distribution*.

Density Estimates

For purposes of impacts analysis, the number of marine mammals potentially affected may be considered in terms of density, which is the number of animals present in the area affected by a given surface detonation. A significant amount of effort is required to collect and analyze survey data sufficient for producing useable marine species density estimates for large areas such as the HRC and is typically beyond the scope of any single organization. As a result, there is often no single source of density available for every area, species, and season of interest; density data are often compiled from multiple sources. The density estimates used for acoustic analysis in this document are from the U.S. Navy's Marine Species Density Database for the Pacific region, which includes the HRC (U.S. Department of the Navy, 2014). The Navy database includes a compilation of the best available density data from several primary sources and published works including survey data from NMFS within the U.S. Exclusive Economic Zone (EEZ) off the coast of Hawaii (hereafter referred to as the Hawaiian Islands EEZ). NMFS publishes annual stock assessment reports for various regions of U.S. waters, which cover all stocks of marine mammals within those waters (for abundance and distribution information on species potentially occurring within the Study Area, see Allen and Angliss [2014] and Carretta et al. [2015]). Other researchers often publish density data or research covering a particular marine mammal species or geographic area, which is integrated into the stock assessment reports.

For most marine mammal species, abundance is estimated using line-transect methods that derive densities based on sighting data collected during systematic ship or aerial surveys. Habitat-based models may also be used to model density as a function of environmental variables. Each source of data may use different methods to estimate density, and uncertainty in the estimate can be directly related to the method applied. Uncertainty in published density estimation is typically large because of the low number of sightings collected during surveys. Uncertainty characterization is an important consideration in marine mammal density estimation and some methods inherently result in greater uncertainty than others. Therefore, in selecting the best density value for a species, area, and time, it is important to select the data source that used a method providing the least uncertainty and the best estimate for the geographic area. A discussion of methods that provide the best estimate with the least uncertainty under different scenarios is provided in the Navy's density database technical report (U.S. Department of the Navy, 2014). For this LOA request, the Navy provided their most recent information on the type of model used to estimate density, along with the sources of uncertainty (expressed as a coefficient of variation), for each marine mammal species in the Hawaii region as part of their latest updates to the Navy Marine Species Density Database (NMSDD). At the time of writing this LOA Request, the latest technical report for the updated NMSDD was still under development, so the source documents for the coefficient of variation values may be more recent than the currently available NMSDD technical report referenced above. This most recent information is reproduced in Table 3-3.

Table 3-3. Marine Mammal Density Models and Uncertainty Values for the Hawaii Region

Species	Coefficient of Variation	Source	Model Type
Humpback whale	Main: 0.15 Outer strata and transit boxes: 0.30	Main Hawaii Islands inner stratum: Mobley, Spitz, et al. (2001) Outer strata and transit boxes: Calambokidis et al. (2008)	Main Hawaii Islands: line-transect Outer EEZ: mark-recapture
Blue whale	1.09	Bradford et al. (in review)	Multiple-covariate line-transect
Fin whale	1.05	Bradford et al. (in review)	Multiple-covariate line-transect
Sei whale	0.90	Bradford et al. (in review)	Multiple-covariate line-transect
Bryde's whale	Spatially-explicit	Forney et al. (2015)	Habitat-based density model
Minke whale	n/a	n/a	Acoustically derived from hydrophones using correction factors (Martin et al., 2015)
Sperm whale	Spatially-explicit	Forney et al. (2015)	Habitat-based density model
Pygmy sperm whale	1.12	Barlow (2006)	Multiple-covariate line-transect
Dwarf sperm whale	0.74	Barlow (2006)	Multiple-covariate line-transect
Killer whale	0.96	Bradford et al. (in review)	Multiple-covariate line-transect
False killer whale (Main Hawaiian Islands insular stock)	0.20	Oleson et al. (2010)	Population Viability Analysis
False killer whale (all other stocks)	Spatially-explicit	Forney et al. (2015)	Habitat-based density model
Pygmy killer whale	0.53	Bradford et al. (in review)	Multiple-covariate line-transect

Table 3-3. Marine Mammal Density Models and Uncertainty Values for the Hawaii Region, Cont'd

Species	Coefficient of Variation	Source	Model Type
Short-finned pilot whale	Spatially-explicit	Forney et al. (2015)	Habitat-based density model
Melon-headed whale	0.20	Aschettino (2010)	Mark-recapture
Bottlenose dolphin	Spatially-explicit	Forney et al. (2015)	Habitat-based density model
Pantropical spotted dolphin	Spatially-explicit	Forney et al. (2015)	Habitat-based density model
Striped dolphin	Spatially-explicit	Forney et al. (2015)	Habitat-based density model
Spinner dolphin	Spatially-explicit	Forney et al. (2015)	Habitat-based density model
Rough-toothed dolphin	Spatially-explicit	Forney et al. (2015)	Habitat-based density model
Fraser's dolphin	0.66	Bradford et al. (in review)	Multiple-covariate line-transect
Risso's dolphin	0.43	Bradford et al. (in review)	Multiple-covariate line-transect
Cuvier's beaked whale	0.69	Bradford et al. (in review)	Multiple-covariate line-transect
Blainville's beaked whale	1.13	Bradford et al. (in review)	Multiple-covariate line-transect
Longman's beaked whale	0.66	Bradford et al. (in review)	Multiple-covariate line-transect
Hawaiian monk seal	n/a	n/a	Navy derived

n/a = not available; EEZ = Exclusive Economic Zone

The NMSDD is considered the most relevant information source available for the Hawaii area and has been used in impacts analysis of previous military actions conducted near the Study Area. For some species, density estimates are uniform throughout the Hawaii region. For others, densities are provided in multiple smaller blocks. In these cases, the Air Force used density estimates corresponding to the block containing the Long Range Strike WSEP impact location. The resulting marine mammal seasonal density estimates used in this document are shown in Table 3-4. Long Range Strike WSEP missions are generally planned to occur in summer, and summer densities (June to August) are, therefore, considered most applicable. Assuming a summer timeframe results in a density estimate of zero for most baleen whales, which are expected to be at higher latitude feeding grounds at that time.

Table 3-4. Marine Mammal Density Estimates

Species	Density Estimate (animals per square kilometer)			
	Fall	Spring	Summer	Winter
Humpback whale	0.02110	0.02110	0	0.02110
Blue whale	0.00005	0.00005	0	0.00005
Fin whale	0.00006	0.00006	0	0.00006
Sei whale	0.00016	0.00016	0	0.00016
Bryde's whale	0.00010	0.00010	0.00010	0.00010
Minke whale	0.00423	0.00423	0	0.00423
Sperm whale	0.00156	0.00156	0.00156	0.00156
Pygmy sperm whale	0.00291	0.00291	0.00291	0.00291
Dwarf sperm whale	0.00714	0.00714	0.00714	0.00714
Killer whale	0.00006	0.00006	0.00006	0.00006
False killer whale (Main Hawaiian Islands insular stock)	0.00080	0.00080	0.00080	0.00080
False killer whale (all other stocks)	0.00071	0.00071	0.00071	0.00071
Pygmy killer whale	0.00440	0.00440	0.00440	0.00440

Table 3-4. Marine Mammal Density Estimates, Cont'd

Species	Density Estimate (animals per square kilometer)			
	Fall	Spring	Summer	Winter
Short-finned pilot whale	0.00919	0.00919	0.00919	0.00919
Melon-headed whale	0.00200	0.00200	0.00200	0.00200
Bottlenose dolphin	0.00316	0.00316	0.00316	0.00316
Pantropical spotted dolphin	0.00622	0.00622	0.00622	0.00622
Striped dolphin	0.00335	0.00335	0.00335	0.00335
Spinner dolphin	0.00204	0.00204	0.00204	0.00204
Rough-toothed dolphin	0.00470	0.00470	0.00470	0.00470
Fraser's dolphin	0.00457	0.00457	0.00457	0.00457
Risso's dolphin	0.00470	0.00470	0.00470	0.00470
Cuvier's beaked whale	0.00030	0.00030	0.00030	0.00030
Blainville's beaked whale	0.00086	0.00086	0.00086	0.00086
Longman's beaked whale	0.00310	0.00310	0.00310	0.00310
Hawaiian monk seal	0.00003	0.00003	0.00003	0.00003

This page is intentionally blank.

4.0 AFFECTED SPECIES STATUS AND DISTRIBUTION

This section provides information on the marine mammal species with potential occurrence in the Study Area. Information is provided for individual species and for stocks when applicable. The MMPA defines a marine mammal "stock" as "a group of marine mammals of the same species or smaller taxon in a common spatial arrangement that interbreed when mature." For MMPA management purposes, a stock is considered an isolated population or group of individuals within a whole species that is found in the same area. However, due to lack of sufficient information, NMFS' recognized management stocks may include groups of multiple species, such as with two *Kogia* species. Marine mammal species may also be managed according to distinct population segments (DPS). A DPS is a population or group of populations that is discrete from other populations of the species and which is significant in relation to the species as a whole.

Up to 25 marine mammal species may occur in the Study Area, including 6 mysticetes (baleen whales), 18 odontocetes (dolphins and toothed whales), and 1 pinniped. Multiple stocks are designated in the Hawaii region for some of these species, resulting in a total of 40 stocks managed by NMFS or the U.S. Fish and Wildlife Service (USFWS) in the Hawaiian Islands EEZ. Many of the stock boundaries are based on water depth or distance from shore. Therefore, due to the Long Range Strike WSEP impact site location, not all stocks coincide with the mission area. Certain stocks of melon-headed whale, bottlenose dolphin, pantropical spotted dolphin, and spinner dolphin are excluded based on these criteria. Three false killer whale stocks occur in the vicinity of the Hawaiian Islands and one of these, the Main Hawaiian Islands Insular stock, is listed as endangered under the ESA. The offshore boundary for this stock is delineated at a maximum distance of 39 NM (72 km) offshore. For 2017–2021 missions, the behavioral harassment threshold range extends into this stock boundary by less than 2 km. No other threshold ranges extend into the stock boundary. Therefore, the Main Hawaiian Islands Insular stock is included in the evaluation of potential behavioral effects in this document. The remaining two false killer whale stocks (Northwestern Hawaiian Islands and Hawaii Pelagic) are evaluated for potential impacts associated with all detonation-related pressure and energy criteria.

Species for which some stocks in the Hawaii region are excluded from consideration, and the rationale for inclusion or exclusion, is provided in Table 4-1. All species and stocks occurring in the Hawaii region are shown in Table 4-2. Information on status, distribution, abundance, and ecology of each species is presented in the following subsections. The North Pacific right whale (*Eubalaena japonica*) is not included in the table or in impacts analyses provided later in this document. This species is considered "vagrant" in the area, as the Hawaii region is currently outside the typical geographic range (Reilly et al., 2008). The most recent known sightings in the Hawaii region occurred in 1996 and 1979 (Salden and Mickelsen, 1999; Herman et al., 1980; Rowntree et al., 1980).

In some instances in this section, references are made to various regions of the Pacific Ocean delineated by the National Oceanic and Atmospheric Administration (NOAA)/NMFS Science Centers. The Eastern North Pacific is the area in the Pacific Ocean that is east of 140 degrees (°) west (W) longitude and north of the equator. Similarly the Central North Pacific is the area north of the equator and between the International Date Line (180° W longitude) and 140° W longitude. The Eastern Tropical Pacific is the area roughly extending from the U.S.-Mexico Border west to Hawaii and south to Peru.

Table 4-1. Occurrence of Marine Mammal Species with Multiple Designated Stocks

Species	Stock[1]	Stock Boundary Designation	Occurrence in Mission Area (44 NM/81 km offshore, water depth 4,645 m)	
			Present	Not Present
False killer whale (*Pseudorca crassidens*)	Main Hawaiian Islands Insular	Animals inhabiting waters within 72 km (39 NM) of the Main Hawaiian Islands	X[2]	
	Northwestern Hawaiian Islands	Animals inhabiting waters within a 93-km (50-NM) radius of the Northwestern Hawaiian Islands, or the boundary of the Papahānaumokuākea Marine National Monument, with the radial boundary extended to the southeast to encompass Kauai and Niihau	X	
	Hawaii Pelagic	Animals inhabiting waters greater than 11 km (6 NM) from the Main Hawaiian Islands (there is no inner boundary within the Northwestern Hawaiian Islands)	X	
Melon-headed whale (*Peponocephala electra*)	Hawaiian Islands	Animals inhabiting waters throughout the U.S. EEZ of the Hawaiian Islands	X	
	Kohala Resident	Animals off the Kohala Peninsula and west coast of Hawaii Island and in less than 2,500-m water depth		X
Bottlenose dolphin (*Tursiops truncatus*)	Hawaii Pelagic	Animals inhabiting waters throughout the U.S. EEZ of the Hawaiian Islands	X	
	Kauai and Niihau Oahu 4-Island Hawaii Island	Animals occurring from the shoreline of the respective islands to 1,000-m water depth		X
Pantropical spotted dolphin (*Stenella attenuata*)	Hawaii Pelagic	Animals inhabiting waters throughout the U.S. EEZ of the Hawaiian Islands, outside of the insular stock areas	X	
	Oahu 4-Island	Animals occurring from the shoreline of the respective islands to 20 km offshore		X
	Hawaii Island	Animals occurring from the shoreline to 65 kilometers offshore of Hawaii Island		X
Spinner dolphin (*Stenella longirostris*)	Hawaii Pelagic	Animals inhabiting waters throughout the U.S. EEZ of the Hawaiian Islands, outside of island-associated stock boundaries	X	
	Hawaii Island Oahu and 4-Island Kauai and Niihau Midway Atoll/Kure Pearl and Hermes Reef	Animals occurring within 10 NM (19 km) of shore of the respective islands		X

EEZ = Exclusive Economic Zone; km = kilometer; m = meter; NM = nautical mile
[1]Stock designations and boundaries were obtained from Carretta et al., 2015.
[2]Evaluated for potential behavioral harassment effects only.

Table 4-2. Status of Marine Mammals in the Study Area

Common Name	Scientific Name	Stock	Stock Abundance (CV)[4]	Study Area Abundance (CV)[4]	Occurrence	ESA/MMPA Status
Mysticetes (baleen whales)						
Humpback whale[1]	*Megaptera novaeangliae*	Central North Pacific	10,103 (N/A)	4,491 (N/A)	Seasonal; throughout known breeding grounds during winter and spring (most common November through April)	Endangered/Depleted
Blue whale[2]	*Balaenoptera musculus*	Central North Pacific	81 (summer/fall) (1.14)	81 (summer/fall) (1.14)	Seasonal; infrequent winter migrant; few sightings, mainly fall and winter; considered rare	Endangered/Depleted
Fin whale[2]	*Balaenoptera physalus*	Hawaii	58 (summer/fall) (1.12)	58 (summer/fall) (1.12)	Seasonal, mainly fall and winter; considered rare	Endangered/Depleted
Sei whale[2]	*Balaenoptera borealis*	Hawaii	178 (summer/fall) (0.90)	178 (summer/fall) (0.90)	Rare; limited sightings of seasonal migrants that feed at higher latitudes	Endangered/Depleted
Bryde's whale[2]	*Balaenoptera brydei/edeni*	Hawaii	798 (0.28)	798 (0.28)	Uncommon; distributed throughout the Hawaiian EEZ	N/A
Minke whale[2]	*Balaenoptera acutorostrata*	Hawaii	No data	No data	Regular but seasonal (October-April)	N/A
Odontocetes (toothed whales and dolphins)						
Sperm whale[2]	*Physeter macrocephalus*	Hawaii	3,354 (0.34)	3,354 (0.34)	Widely distributed year-round; more likely in waters > 1,000 m depth, most often > 2,000 m	Endangered/Depleted
Pygmy sperm whale[2]	*Kogia breviceps*	Hawaii	No data	No data	Stranding numbers suggest this species is more common than previous survey sightings indicated	N/A

Table 4-2. Status of Marine Mammals in the Study Area, Cont'd

Common Name	Scientific Name	Stock	Stock Abundance (CV)[4]	Study Area Abundance (CV)[4]	Occurrence	ESA/MMPA Status
Dwarf sperm whale[2]	*Kogia sima*	Hawaii	No data	No data	Stranding numbers suggest this species is more common than previous survey sightings indicated	N/A
Killer whale[2]	*Orcinus orca*	Hawaii	101 (1.00)	101 (1.00)	Uncommon; infrequent sightings	N/A
False killer whale Hawaiian Islands Stock Complex[3]	*Pseudorca crassidens*	Main Hawaiian Islands Insular	151 (0.20)	151 (0.20)	Regular	Endangered/Depleted
		Hawaii Pelagic	1,540 (0.67)	1,540 (0.67)	Regular	N/A
		Northwestern Hawaiian Islands	617 (1.11)	617 (1.11)	Regular	N/A
Pygmy killer whale[2]	*Feresa attenuata*	Hawaii	3,433 (0.52)	3,433 (0.52)	Year-round resident	N/A
Short-finned pilot whale[2]	*Globicephala macrorhynchus*	Hawaii	12,422 (0.43)	12,422 (0.43)	Commonly observed around Main Hawaiian Islands and Northwestern Hawaiian Islands	N/A
Melon-headed whale Hawaiian Islands Stock Complex[2]	*Peponocephala electra*	Hawaii Islands stock	5,794 (0.20)	5,794 (0.20)	Regular	N/A
		Kohala Resident Stock	447 (0.12)	Not applicable to study area	Regular	N/A
Bottlenose dolphin Hawaiian Islands Stock Complex[2]	*Tursiops truncatus*	Hawaii Pelagic	5,950 (0.59)	5,950 (0.59)	Common in deep offshore waters	N/A
		Kauai and Niihau	147 (0.11)	Not applicable to study area	Common in shallow nearshore waters ≤ 1,000 m depth)	N/A
		Oahu	594 (0.54)	Not applicable to study area	Common in shallow nearshore waters ≤ 1,000 m depth)	N/A
		4-Island Region	153 (0.24)	Not applicable to study area	Common in shallow nearshore waters ≤ 1,000 m depth)	N/A

Table 4-2. Status of Marine Mammals in the Study Area, Cont'd

Common Name	Scientific Name	Stock	Stock Abundance (CV)[4]	Study Area Abundance (CV)[4]	Occurrence	ESA/MMPA Status
		Hawaii Island	102 (0.13)	Not applicable to study area	Common in shallow nearshore waters ≤ 1,000 m depth)	N/A
Pantropical spotted dolphin Hawaiian Islands Stock Complex[2]	*Stenella attenuata*	Hawaii Pelagic	15,917 (0.40)	15,917 (0.40)	Common; primary occurrence between 100 and 4,000 m depth	N/A
		Oahu	No data	Not applicable to study area	Common; primary occurrence between 100 and 4,000 m depth	N/A
		4-Island Region	No data	Not applicable to study area	Common; primary occurrence between 100 and 4,000 m depth	N/A
		Hawaii Island	No data	Not applicable to study area	Common; primary occurrence between 100 and 4,000 m depth	N/A
Striped dolphin[2]	*Stenella coeruleoalba*	Hawaii	20,650 (0.36)	20,650 (0.36)	Occurs regularly year-round but infrequent sighting during survey (Barlow, 2006)	N/A
Spinner dolphin Hawaiian Islands Stock Complex[2]	*Stenella longirostris*	Hawaii Pelagic	No data	No data	Common year-round in offshore waters	N/A
		Hawaii Island	631 (0.09)	Not applicable to study area	Common year-round; rest in nearshore waters during the day and move offshore to feed at night	N/A
		Oahu and 4-Island	355 (0.09)	Not applicable to study area	Common year-round; rest in nearshore waters during the day and move offshore to feed at night	N/A
		Kauai and Niihau	601 (0.20)	Not applicable to study area	Common year-round; rest in nearshore waters during the day and move offshore to feed at night	N/A

Table 4-2. Status of Marine Mammals in the Study Area, Cont'd

Common Name	Scientific Name	Stock	Stock Abundance (CV)[4]	Study Area Abundance (CV)[4]	Occurrence	ESA/MMPA Status
		Midway Atoll/Kure	No data	Not applicable to study area	Common year-round; rest in nearshore waters during the day and move offshore to feed at night	N/A
		Pearl and Hermes Reef	No data	Not applicable to study area	Common year-round; rest in nearshore waters during the day and move offshore to feed at night	N/A
Rough-toothed dolphin[2]	*Steno bredanensis*	Hawaii Stock (Hawaiian Islands EEZ)	6,288 (0.39)	6,288 (0.39)	Common throughout the Main Hawaiian Islands and Hawaii EEZ	N/A
		Kauai/Niihau area (not a designated stock)	1,665 (0.33)	1,665 (0.33)	Common throughout the Main Hawaiian Islands and Hawaii EEZ	N/A
		Hawaii Island (not a designated stock)	198 (0.12)	Not applicable to study area	Common throughout the Main Hawaiian Islands and Hawaii EEZ	N/A
Fraser's dolphin[2]	*Lagenodelphis hosei*	Hawaii	16,992 (0.66)	16,992 (0.66)	Tropical species only recently documented within Hawaii EEZ (2002 survey)	N/A
Risso's dolphin[2]	*Grampus griseus*	Hawaii	7,256 (0.41)	7,256 (0.41)	Previously considered rare but multiple sightings in Hawaii EEZ during various surveys conducted from 2002-2012	N/A
Cuvier's beaked whale[2]	*Ziphius cavirostris*	Hawaii	1,941 (0.70)	1,941 (0.70)	Year-round occurrence but difficult to detect due to diving behavior	N/A
Blainville's beaked whale[2]	*Mesoplodon densirostris*	Hawaii	2,338 (1.13)	2,338 (1.13)	Year-round occurrence but difficult to detect due to diving behavior	N/A

Table 4-2. Status of Marine Mammals in the Study Area, Cont'd

Common Name	Scientific Name	Stock	Stock Abundance (CV)[4]	Study Area Abundance (CV)[4]	Occurrence	ESA/MMPA Status
Longman's beaked whale[2]	*Indopacetus pacificus*	Hawaii	4,571 (0.65)	4,571 (0.65)	Considered rare; however, multiple sightings during 2010 survey	N/A
Pinnipeds						
Hawaiian monk seal[2]	*Neomonachus schauinslandi*	Hawaii	1,153 (Northwestern Hawaiian Islands)	138 (Main Hawaiian Islands)	Predominantly occur at Northwestern Hawaiian Islands; approximately 138 in Main Hawaiian Islands	Endangered/Depleted

≤ = less than or equal to; CV = coefficient of variation; EEZ = Exclusive Economic Zone; ESA = Endangered Species Act; m = meters; MMPA = Marine Mammal Protection Act; N/A = not applicable

[1]Stock designations and abundance were obtained from Allen and Angliss, 2014.

[2]Stock designations and abundance were obtained from Carretta et al., 2015.

[3]Stock designations were obtained from Carretta et al., 2015 and Bradford et al., 2015; abundance was obtained from Bradford et al., 2015.

[4]The stated coefficient of variation (CV) is an indicator of uncertainty in the abundance estimate and describes the amount of variation with respect to the statistical population mean. It is expressed as a fraction or percentage and can range upward from zero (no uncertainty) to high values (greater uncertainty). For example, a CV of 0.8 would indicate much higher uncertainty than a CV of 0.2. When the CV reaches or exceeds 1.0, the estimate is highly uncertain, as the variation could be 100 percent or more of the estimated abundance. The uncertainty associated with movements of animals into or out of an area (due to factors such as prey availability or oceanographic conditions) is much larger than is indicated by the statistical CVs that are given.

4.1 Humpback Whale (*Megaptera novaeangliae*)

Status and Management

Humpback whales are currently listed as depleted under the MMPA and endangered under the ESA. In the U.S. North Pacific Ocean, the stock structure of humpback whales is defined based on feeding areas because of the species' fidelity to feeding grounds (Carretta et al., 2015). Three stocks are currently designated by NMFS in the North Pacific: (1) the Central North Pacific stock, consisting of winter and spring populations of the Hawaiian Islands that migrate to northern British Columbia and Alaska, the Gulf of Alaska, the Bering Sea, and Aleutian Islands; (2) the Western North Pacific stock, consisting of winter and spring populations off Asia that migrate to Russia and the Bering Sea and Aleutian Islands; and (3) the California/Oregon/Washington stock, consisting of animals along the U.S. west coast.

However, in April 2015, NMFS announced a proposal to divide the species into 14 DPSs worldwide, including a Hawaii DPS, and to revise the listing status for the various populations (50 Code of Federal Regulations (CFR) Parts 223 and 224, 21 April 2015). Under the proposal, two DPSs would be designated as endangered under the ESA, two would be designated as threatened, and the remainder would not have an ESA listing status. The proposed Hawaii DPS, which is the same as the current Central North Pacific stock, is not included in the four DPSs that would be listed under the ESA. NMFS does not consider the proposed Hawaii DPS to be in danger of extinction or likely to become so in the foreseeable future. Therefore, the DPS would not be listed as endangered or threatened under the proposed revision. At the time this document was prepared, NMFS was soliciting public comment on the proposed rule.

The Hawaiian Islands Humpback Whale National Marine Sanctuary, which was designated in 1992 to protect humpback whales and their habitat, is located within the HRC. The sanctuary is delineated from the shoreline to the 100-fathom (183-m) isobath in discrete areas of the Hawaiian Islands region, including an area off the north shore of Kauai. However, the sanctuary does not coincide with the Long Range Strike WSEP mission location, which is located in water depth of over 4,600 meters.

Geographic Range and Distribution

General. Humpback whales are distributed worldwide in all major oceans and most seas. They typically are found during the summer in high-latitude feeding grounds and during the winter in the tropics and subtropics around islands, over shallow banks, and along continental coasts, where calving occurs.

Insular Pacific-Hawaiian Large Marine Ecosystem. The Central North Pacific stock of humpback whales occurs throughout known breeding grounds in the Hawaiian Islands during winter and spring (November through April) (Allen and Angliss, 2013). Peak occurrence is from late February through early April (Carretta et al., 2010; Mobley et al., 2000), with a peak in acoustic detections in March (Norris et al., 1999). A recent study that also used acoustic recordings near the Northwestern Hawaiian Islands indicates that humpback whales were present from early December through early June (Lammers et al., 2011). During the fall-winter period, primary occurrence is expected from the coast to 50 NM offshore (Mobley et al., 2000; Mobley, 2004). The greatest densities of humpback whales (including calves) are in the four-island region consisting of Maui, Molokai, Kahoolawe, and Lanai, as well as Penguin Bank (Mobley et al., 2000; Maldini et al., 2005) and around Kauai (Mobley, 2005). During the spring-summer period, secondary occurrence is expected offshore out to 50 NM. Occurrence farther offshore or inshore (e.g., Pearl Harbor) has rarely been documented.

Survey results suggest that humpbacks may also be wintering in the northwestern Hawaiian Island region and not just using it as a migratory corridor. A recent study that also used acoustic recordings near the Northwestern Hawaiian Islands indicates that humpback whales were present from early December through early June (Lammers et al., 2011). It is not yet known if this represents a previously undocumented breeding stock or if the whales occurring at the Northwestern Hawaiian Islands are part of the same population that winters near the Main Hawaiian Islands.

In breeding grounds, females with calves occur in significantly shallower waters than other groups of whales, and breeding adults use deeper more offshore waters (Smultea, 1994; Ersts and Rosenbaum, 2003). The habitat requirements of wintering humpbacks appear to be controlled by the conditions necessary for calving, such as warm water (75 to 80 ° Fahrenheit [24° to 28° Celsius]) and relatively shallow, low-relief ocean bottom in protected areas created by islands or reefs (Smultea, 1994; Clapham, 2000; Craig and Herman, 2000).

Open Ocean. Most humpback whale sightings are in nearshore and continental shelf waters; however, humpback whales frequently travel through deep oceanic waters during migration (Calambokidis et al., 2001; Clapham and Mattila, 1990; Clapham, 2000). Humpback migrations are complex and cover long distances (Calambokidis, 2009; Barlow et al., 2011). Each year, most humpback whales migrate from high-latitude summer feeding grounds to low-latitude winter breeding grounds, one of the longest migrations known for any mammal; individuals can travel nearly 4,970 miles (7,998.4 km) from feeding to breeding areas (Clapham and Mead, 1999). Humpback whales that breed in Hawaii generally migrate to northern British Columbia and southeast Alaska to feed. Animals breeding in Hawaii have also been "matched" (identified as the same individual) to humpbacks feeding in southern British Columbia and northern Washington (where matches were also found to animals breeding in Central America). Hawaii humpbacks are also known to feed in the Gulf of Alaska, the Aleutian Islands, and Bering Sea, where surprisingly, matches were also found to animals that breed near islands off Mexico (Forestell and Urban-Ramirez, 2007; Barlow et al., 2011; Lagerquist et al., 2008) and between Japan and Hawaii (Salden et al., 1999). This study indicates that humpback whales migrating between Hawaii and British Columbia/southeast Alaska must cross paths with humpback whales migrating between the Gulf of Alaska/Aleutian Islands/Bering Sea and islands off Mexico. In addition, based on the identification of individual whales, there is evidence that some humpback whales (most likely males) move between winter breeding areas in Hawaii and Mexico (Forestall and Urban-Ramirez, 2007) and Hawaii and Japan (Salden et al., 1999).

Satellite tagging of humpback whales in the Hawaiian Islands found that one adult traveled 155 miles (249.4 km) to Oahu, Hawaii, in 4 days, while a different individual traveled to Penguin Bank and five islands, totaling 530 miles (852.9 km) in 10 days. Both of these trips imply faster travel between the islands than had been previously recorded (Mate et al., 1998). Three whales traveled independent courses, following north and northeast headings toward the Gulf of Alaska, with the fastest averaging 93 miles (150 km) per day. At this rate, the animal would take an estimated 39 days to travel the entire 2,600-mile (4,200-km) migration route to the upper Gulf of Alaska (Mate et al., 1998).

Population and Abundance

The overall abundance of humpback whales in the north Pacific was recently estimated at 21,808 individuals (coefficient of variation [CV] = 0.04; this is an indicator of statistical uncertainty and is described in the footnote in Table 4-2), confirming that this population of humpback whales has continued to increase and is now greater than some pre-whaling abundance estimates (Barlow et al., 2011). Data indicate the north Pacific population has been increasing at a rate of between 5.5 percent and 6.0 percent per year, approximately doubling every 10 years (Calambokidis et al., 2008). The Central North Pacific stock has been estimated at 10,103 individuals on wintering grounds throughout the Main Hawaiian Islands (Allen and Angliss, 2013). The Hawaiian Islands Humpback Whale National Marine Sanctuary reported in 2010 that over 50 percent of the entire North Pacific humpback whale population migrates to Hawaiian waters each year (NOAA, 2010). Based on aerial surveys conducted around the Main Hawaiian Islands, the number of humpback whales was estimated at 4,491 (Mobley, Spitz, et al., 2001).

Predator/Prey Interactions

The most common invertebrate prey are krill (tiny crustaceans); the most common fish prey are herring, mackerel, sand lance, sardines, anchovies, and capelin (Clapham and Mead, 1999). Feeding occurs both at the surface and in deeper waters, wherever prey is abundant. Humpback whales are the only species of baleen whale that show strong evidence of cooperation when they feed in large groups (D'Vincent et al., 1985). It is believed that minimal feeding occurs in wintering grounds, such as the Hawaiian Islands (Balcomb, 1987; Salden, 1989). This species is known to be attacked by both killer whales and false killer whales as evidenced by tooth rake scars on their bodies and fins (Jefferson et al., 2015).

Species-Specific Threats

Entanglement in fishing gear poses a threat to individual humpback whales throughout the Pacific. Humpback whales from the Central North Pacific stock have been reported seriously injured and killed from entanglement in fishing gear while in their Alaskan feeding grounds (Allen and Angliss, 2013). From 2003 to 2007, an average of 3.4 humpback whales per year were seriously injured or killed due to entanglements with commercial fishing gear in Alaskan waters. This number is considered a minimum since observers have not been assigned to several fisheries known to interact with this stock and quantitative data on Canadian fishery entanglements are uncertain (Allen and Angliss, 2013). In the Hawaiian Islands, there are also reports of humpback whale entanglements with fishing gear. Between 2002 and 2014, the Hawaiian Islands Disentanglement Network responded to 139 confirmed large whale entanglement reports (Hawaiian Islands Humpback Whale National Marine Sanctuary, 2014). All but three of the reports (a sei whale and two sperm whales) involved humpback whales. In the 2013–2014 season, at least 13 whales were reported as entangled, with fishing gear (crab trap and longline gear) confirmed in three of the events.

Humpback whales, especially calves and juveniles, are highly vulnerable to ship strikes. Younger whales spend more time at the surface, are less visible, and are found closer to shore (Herman et al., 1980; Mobley et al., 1999), thereby making them more susceptible to collisions. In their Alaskan feeding grounds, eight ship strikes were implicated in mortality or serious injuries of humpback whales between 2003 and 2007 and seven between 2006 and 2010 (Allen and Angliss, 2011; Allen and Angliss, 2013); when they migrate to and from Alaska, some of these whales spend time in Hawaii.

In the Hawaiian Islands, there were nine reported ship collisions with humpback whales in 2006 (none involved Navy vessels), as recorded by the NMFS Pacific Islands Region Marine Mammal Response Network Activity Updates (NMFS, 2007a). The number of confirmed ship strike reports was greater in 2007/2008; there were 12 reported ship-strikes with humpback whales: 9 reported as hit by vessels and 3 observed with wounds indicating a recent ship strike (NMFS, 2008). A humpback carcass was discovered on the shore of west Molokai in 2010 with indications that the death resulted from trauma consistent with a ship strike (NMFS, 2010a).

Humpback whales are potentially affected by loss of habitat, loss of prey, underwater noise, and pollutants. The Central North Pacific stock of humpback whales is the focus of whale-watching activities in both its feeding grounds (Alaska) and breeding grounds (Hawaii). Regulations addressing minimum approach distances and vessel operating procedures are in place to help protect the whales; however, there is still concern that whales may abandon preferred habitats if the disturbance is too high (Allen and Angliss, 2010).

4.2 Blue Whale (*Balaenoptera musculus*)

The world's population of blue whales can be separated into three subspecies, based on geographic location and some morphological differences. The true blue whales have been divided into two subspecies found in the northern hemisphere (*Balaenoptera musculus musculus*) and the southern hemisphere (*Balaenoptera musculus intermedia*). The third subspecies, the pygmy blue whale (*Balaenoptera musculus brevicauda*), is known to have overlapping ranges with both subspecies of true blue whales (Best et al., 2003; Reeves et al., 2002).

Status and Management

The blue whale is listed as endangered under the ESA and as depleted under the MMPA. For the MMPA stock assessment reports, the Central North Pacific Stock of blue whales includes animals found around the Hawaiian Islands during winter (Carretta et al., 2015).

Geographic Range and Distribution

General. The blue whale inhabits all oceans and typically occurs near the coast, over the continental shelf, though it is also found in oceanic waters. Their range includes the California Current and Insular Pacific-Hawaiian Large Marine Ecosystems and the open ocean. Blue whales have been sighted, acoustically recorded, and satellite tagged in the eastern tropical Pacific (Ferguson, 2005; Stafford et al., 2004).

Insular Pacific-Hawaiian Large Marine Ecosystem. Blue whales are found seasonally in the Hawaii region, but sighting frequency is low. Whales feeding along the Aleutian Islands of Alaska likely migrate to offshore waters north of Hawaii in winter.

Open Ocean. Most blue whale sightings are in nearshore and continental shelf waters; however, blue whales frequently travel through deep oceanic waters during migration (Širović et al., 2004). Most baleen whales spend their summers feeding in productive waters near the higher latitudes and winters in the warmer waters at lower latitudes (Širović et al., 2004). Blue whales belonging to the western Pacific stock may feed in summer, south of the Aleutians and in the Gulf of Alaska, and migrate to wintering grounds in lower latitudes in the western Pacific and central Pacific, including Hawaii (Stafford et al., 2004; Watkins et al., 2000).

Population and Abundance

In the north Pacific, up to five distinct populations of blue whales are believed to occur, although only one stock is currently identified. The overall abundance of blue whales in the eastern tropical Pacific is estimated at 1,400 individuals. The most recent survey data indicate a summer/fall abundance estimate of 81 individuals (CV = 1.14) in the Hawaiian Islands EEZ (Carretta et al., 2015). This estimate could potentially be low, as the majority of blue whales would be expected to be at higher latitude feeding grounds at that time.

Predator/Prey Interactions

This species preys almost exclusively on various types of zooplankton, especially krill. Blue whales lunge feed and consume approximately 6 tons (5,500 kilograms) of krill per day (Jefferson et al., 2015; Pitman et al., 2007). They sometimes feed at depths greater than 330 feet (100 m), where their prey maintains dense groupings (Acevedo-Gutiérrez et al., 2002). Blue whales have been documented to be preyed on by killer whales (Jefferson et al., 2015; Pitman et al., 2007). There is little evidence that killer whales attack this species in the north Atlantic or southern hemisphere, but 25 percent of photo-identified whales in the Gulf of California carry rake scars from killer whale attacks (Sears and Perrin, 2008).

Species-Specific Threats

Blue whales are considered to be susceptible to entanglement in fishing gear and ship strikes.

4.3 Fin Whale (*Balaenoptera physalus*)

Status and Management

The fin whale is listed as endangered under the ESA and as depleted under the MMPA. Pacific fin whale population structure is not well known. In the North Pacific, recognized stocks include the California/Oregon/Washington, Hawaii, and Northeast Pacific stocks (Carretta et al., 2015).

Geographic Range and Distribution

General. The fin whale is found in all the world's oceans and is the second largest species of whale (Jefferson et al., 2015). Fin whales prefer temperate and polar waters and are scarcely seen in warm, tropical waters (Reeves et al., 2002). Fin whales typically congregate in areas of high productivity. They spend most of their time in coastal and shelf waters but can often be found in waters of approximately 6,562 feet (2,000 m) (Aissi et al., 2008; Reeves et al., 2002). Attracted for feeding, fin whales are often seen closer to shore after periodic patterns of upwelling and the resultant increased krill density (Azzellino et al., 2008). This species of whale is not known to have a specific habitat and is highly adaptable, following prey, typically off the continental shelf (Azzellino et al., 2008; Panigada et al., 2008). The range of the fin whale is known to include the Insular Pacific-Hawaiian Large Marine Ecosystems and the open ocean.

Insular Pacific-Hawaiian Large Marine Ecosystem. Fin whales are found in Hawaiian waters, but this species is considered rare in this area (Carretta et al., 2010; Shallenberger, 1981). There are known sightings from Kauai and Oahu and a single stranding record from Maui (Mobley et al., 1996; Shallenberger, 1981; U.S. Department of the Navy, 2011). Summer/fall shipboard surveys of the Hawaiian Islands EEZ resulted in five sightings in 2002 and two sightings in 2010 (Barlow, 2003; Bradford et al., 2013). A single sighting was made during aerial surveys from 1993 to 1998 (Mobley et al., 1996; Mobley et al., 2000). The most recent sighting was a single juvenile fin whale reported off Kauai in 2011 (U.S. Department of the Navy, 2011). Based on sighting data and acoustic recordings, fin whales are likely to occur in Hawaiian waters mainly in fall and winter (Barlow et al., 2006; Barlow et al., 2008; Barlow et al., 2004).

Open Ocean. Fin whales have been recorded in the eastern tropical Pacific (Ferguson, 2005) and are frequently sighted there during offshore ship surveys. Fin whales are relatively abundant in north Pacific offshore waters, including areas off Hawaii (Berzin and Vladimirov, 1981; Mizroch et al., 2009). Locations of breeding and calving grounds for the fin whale are unknown, but it is known that the whales typically migrate seasonally to higher latitudes every year to feed and migrate to lower latitudes to breed (Kjeld et al., 2006; MacLeod, Simmonds, et al., 2006). The fin whale's ability to adapt to areas of high productivity controls migratory patterns (Canese et al., 2006; Reeves et al., 2002). Fin whales are one of the fastest cetaceans, capable of attaining speeds of 25 miles (40.2 km) per hour (Jefferson et al., 2015; Marini et al., 1996).

Population and Abundance

Based on summer/fall surveys in the Hawaiian Islands EEZ, the current best available abundance estimate for the Hawaii stock of fin whales is 58 (CV = 1.12). This may be an underestimate because the majority of blue would be expected to be at higher latitude feeding grounds at the time the surveys were conducted (Carretta et al., 2015).

Predator/Prey Interactions

This species preys on small invertebrates such as copepods, squid, and schooling fishes such as capelin, herring, and mackerel (Goldbogen et al., 2006; Jefferson et al., 2015). The fin whale is not known to have a significant number of predators. However, in regions where killer whales are abundant, some fin whales exhibit attack scars on their flippers, flukes, and flanks, suggesting possible predation by killer whales (Aguilar, 2008).

Species-Specific Threats

Fin whales are susceptible to ship strikes and entanglement in fishing gear.

4.4 Sei Whale (*Balaenoptera borealis*)

The sei whale is a medium-sized rorqual falling in size between fin whale and Bryde's whale and, given the difficulty of some field identifications and similarities in the general appearance of the three species, may sometimes be recorded in surveys as unidentified rorqual.

Status and Management

The sei whale is listed as endangered under the ESA and as depleted under the MMPA. A recovery plan for the sei whale was completed in 2011 and provides a research strategy for obtaining data required to estimate population abundance and trends, and to identify factors that may be limiting the recovery of this species (NMFS, 2011a). Although the International Whaling Commission recognizes one stock of sei whales in the North Pacific, some evidence indicates that more than one population exists. For the MMPA stock assessment reports, sei whales in the Pacific EEZ are divided into three areas: Hawaii, California/Oregon/Washington, and Alaska (Carretta et al., 2015).

Geographic Range and Distribution

General. Sei whales have a worldwide distribution and are found primarily in cold temperate to subpolar latitudes. During the winter, sei whales are found from 20° north (N) to 23° N and during the summer from 35° N to 50° N (Horwood, 2009; Masaki, 1976; Masaki, 1977; Smultea et al., 2010). However, a recent survey of the Northern Mariana Islands recorded sei whales south of 20° N in the winter (Fulling et al., 2011). They are considered absent or at very low densities in most equatorial areas.

Insular Pacific-Hawaiian Large Marine Ecosystem. The first verified sei whale sighting made nearshore of the Main Hawaiian Islands occurred in 2007 (Smultea et al., 2007; Smultea et al., 2010) and included the first subadults seen in the Main Hawaiian Islands. A line-transect survey conducted in February 2009 by the Cetacean Research Program surrounding the Hawaiian Islands resulted in the sighting of three Bryde's/sei whales. An additional sighting occurred in 2010 of Perret Seamount (U.S. Department of Navy, 2011). In March 2011 off Maui, the Hawaiian Islands Entanglement Response Network found a subadult sei whale entangled in rope and fishing gear (NMFS, 2011b). An attempt to disentangle the whale was unsuccessful, although a telemetry buoy attached to the entangled gear was reported to be tracking the whale over 21 days as it moved north and over 250 NM from the Hawaiian Islands.

The sei whale has been considered rare in the Hawaii region based on reported sighting data and the species' preference for cool temperate waters. Sei whales were not sighted during aerial surveys conducted within 25 NM of the Main Hawaiian Islands from 1993 to 1998 (Mobley et al., 2000). Based on sightings made during the NMFS-Southwest Fisheries Science Center shipboard survey assessment of Hawaiian cetaceans (Barlow et al., 2004), sei whales were expected to occur in deep waters on the north side of the islands only. However, in 2007 two sei whale sightings occurred north of Oahu, Hawaii, during a short survey in November, and these included three subadult whales. These latter sightings suggest that the area north of the Main Hawaiian Islands may be part of a reproductive area for north Pacific sei whales (Smultea et al., 2010). Summer/fall shipboard surveys of the Hawaiian Islands EEZ resulted in four sightings in 2002 and three in 2010 (Barlow, 2003; Bradford et al., 2013).

Open Ocean. Sei whales are most often found in deep oceanic waters of the cool temperate zone. They appear to prefer regions of steep bathymetric relief, such as the continental shelf break, canyons, or basins between banks and ledges (Best and Lockyer, 2002; Gregr and Trites, 2001; Kenney and Winn, 1987; Schilling et al., 1992). On feeding grounds, the distribution is largely associated with oceanic frontal systems (Horwood, 1987). Characteristics of preferred breeding grounds are unknown, since they have generally not been identified.

Sei whales spend the summer feeding in high latitude subpolar latitudes and return to lower latitudes to calve in winter. Whaling data provide some evidence of differential migration patterns by reproductive class, with females arriving at and departing from feeding areas earlier than males (Horwood, 1987; Perry et al., 1999). Sei whales are known to swim at speeds greater than 15 miles (25 km) per hour and may be the second fastest cetacean, after the fin whale (Horwood, 2009; Jefferson et al., 2015).

Population and Abundance

Based on summer/fall surveys, the best current estimate of abundance for the Hawaii stock of sei whales is 178 animals (CV = 0.90). This abundance estimate is considered the best available estimate for the Hawaiian Islands EEZ but may be an underestimate, as sei whales are expected to be mostly at higher latitudes on their feeding grounds during this time of year. No data are available on current population trends.

Predator/Prey Interactions

In the north Pacific, sei whales feed on a diversity of prey, including copepods, krill, fish (specifically sardines and anchovies), and cephalopods (squids, cuttlefish, octopuses) (Horwood, 2009; Nemoto and Kawamura, 1977). Feeding occurs primarily around dawn, which appears to be correlated with vertical migrations of prey species (Horwood, 2009). Unlike other rorquals, the sei whale skims to obtain its food, although, like other rorqual species, it does some lunging and gulping (Horwood, 2009).

Sei whales, like other large baleen whales, are likely subject to occasional attacks by killer whales.

Species-Specific Threats

Based on the statistics for other large whales, it is likely that ship strikes also pose a threat to sei whales.

4.5 Bryde's Whale (*Balaenoptera brydei/edeni*)

Bryde's whales are among the least known of the large baleen whales. Their classification and true number remain uncertain (Alves et al., 2010). Until recently, all medium-sized baleen whales were considered members of one of two species, Bryde's whale or sei whale. However, at least three genetically distinct types of these whales are now known, including the so-called pygmy or dwarf Bryde's whales (*Balaenoptera brydei*) (Kato and Perrin, 2008; Rice, 1998). The International Whaling Commission continues to use the name *Balaenoptera edeni* for all Bryde's-like whales, although at least two species are recognized. In 2003, a new species (Omura's whale, *Balaenoptera omurai*) was described, and it became evident that the term pygmy Bryde's whale had been mistakenly used for specimens of *Balaenoptera omurai* (Reeves et al., 2004). Omura's whale is not currently known to occur in the Study Area and appears to be restricted to the western Pacific and Indian Oceans (Jefferson et al., 2015); therefore, it is not described or evaluated in this document.

Status and Management

This species is protected under the MMPA and is not listed under the ESA. The International Whaling Commission recognizes three management stocks of Bryde's whales in the north Pacific: Western North Pacific, Eastern North Pacific, and East China Sea (Donovan, 1991), though the biological basis for defining separate stocks of Bryde's whales in the central north Pacific is not clear (Carretta et al., 2010). For MMPA stock assessment reports, Bryde's whales within the Pacific U.S. EEZ are divided into two areas: Hawaii and Eastern Pacific (Carretta et al., 2015).

Geographic Range and Distribution

Insular Pacific-Hawaiian Large Marine Ecosystem. Bryde's whales are only occasionally sighted in the Insular Pacific-Hawaiian Large Marine Ecosystems (Carretta et al., 2010; Jefferson et al., 2015; Smultea et al., 2008). The first verified Bryde's whale sighting made nearshore of the Main Hawaiian Islands occurred in 2007 (Smultea et al., 2008; Smultea et al., 2010). A line-transect survey conducted in February 2009 by the Cetacean Research Program surrounding the Hawaiian Islands resulted in the sighting of three Bryde's/sei whales (Oleson and Hill, 2009). Summer/fall shipboard surveys of waters within the Hawaiian Islands EEZ in 2002 and 2010 resulted in 13 and 30 Bryde's whale sightings, respectively (Barlow, 2003; Bradford et al., 2013). Sightings are more frequent in the Northwestern Hawaiian Islands than in the Main Hawaiian Islands (Barlow et al., 2004; Carretta et al., 2010; Smultea et al., 2008; Smultea et al., 2010).

Open Ocean. Bryde's whales occur primarily in offshore oceanic waters of the north Pacific. Data suggest that winter and summer grounds partially overlap in the central north Pacific (Kishiro, 1996; Ohizumi et al., 2002). Bryde's whales are distributed in the central north Pacific in summer; the southernmost summer distribution of Bryde's whales inhabiting the central north Pacific is about 20° N (Kishiro, 1996). Some whales remain in higher latitudes (around 25° N) in both winter and summer but are not likely to move poleward of 40° N (Jefferson et al., 2015; Kishiro, 1996). Bryde's whales in some areas of the world are sometimes seen very close to shore and even inside enclosed bays (Baker and Madon, 2007; Best et al., 1984).

Long migrations are not typical of Bryde's whales, although limited shifts in distribution toward and away from the equator, in winter and summer, have been observed (Best, 1996; Cummings, 1985). They have been recorded swimming at speeds of 15 miles (24.1 km) per hour (Jefferson et al., 2015; Kato and Perrin, 2008).

Population and Abundance

Little is known of population status and trends for most Bryde's whale populations. Current genetic research confirms that gene flow among Bryde's whale populations is low and suggests that management actions treat each as a distinct entity to ensure proper conservation of biological diversity (Kanda et al., 2007). A 2010 shipboard line-transect survey of the entire Hawaiian Islands EEZ yielded an abundance estimate of 798 (CV = 0.28) Bryde's whales (Bradford et al., 2013), which is the best available abundance estimate for the Hawaiian stock.

Predator/Prey Interactions

Bryde's whales primarily feed on schooling fish and are lunge feeders. Prey includes anchovy, sardine, mackerel, herring, krill, and other invertebrates such as pelagic red crab (Baker and Madon, 2007; Jefferson et al., 2015; Nemoto and Kawamura, 1977). Bryde's whales have been observed using "bubble nets" to herd prey (Jefferson et al., 2015; Kato and Perrin, 2008). Bubble nets are used in a feeding strategy where the whales dive and release bubbles of air that float up in a column and trap prey inside where they lunge through the column to feed. Bryde's whale is known to be prey for killer whales, as evidenced by an aerial observation of 15 killer whales attacking a Bryde's whale in the Gulf of California (Weller, 2008).

Species-Specific Threats

Serious injury or mortality from interactions with fishing gear poses a threat to Bryde's whales.

4.6 Minke Whale (*Balaenoptera acutorostrata*)

Until recently, all minke whales were classified as the same species. However, the taxonomy is currently complex, as NMFS recognizes two species: northern or common minke whale (*Balaenoptera acutorostrata*) and Antarctic minke whale (*Balaenoptera bonaerensis*) (NOAA, 2014). The dwarf minke whale form (*Balaenoptera acutorostrata* subspecies, no official scientific name) is a possible third species, and there are several other subspecies as well. The northern minke whale is divided into two subspecies, *Balaenoptera acutorostrata scammoni* in the north Pacific and *Balaenoptera acutorostrata acutorostrata* in the north Atlantic. Accordingly, only *Balaenoptera acutorostrata scammoni* occurs in the Study Area. For stock assessment reports, NMFS currently recognizes three stocks in the Pacific U.S. EEZ: Hawaii, California/Oregon/Washington, and Alaska (Carretta et al., 2015).

Status and Management

The minke whale is protected under the MMPA and is not listed under the ESA.

Geographic Range and Distribution

General. The minke whale range is known to include the California Current and Insular Pacific-Hawaiian Large Marine Ecosystems, North Pacific Gyre, and the North Pacific Transition Zone (Okamura et al., 2001; Yamada, 1997). The northern boundary of their range is within subarctic and arctic waters (Kuker et al., 2005).

Insular Pacific-Hawaiian Large Marine Ecosystem. Minke whales previously were considered a rare species in Hawaiian waters due to limited sightings during surveys. The first documented sighting of a minke whale close to the main Hawaiian islands was made off the southwest coast of Kauai in 2005 (Norris et al., 2005; Rankin et al., 2007). However, recent research suggests minke whales are somewhat common in Hawaii (Rankin et al., 2007; U.S. Department of the Navy, 2011). Whales found in the Hawaii region are known to belong to seasonally migrating populations that feed in higher latitudes (Barlow, 2006). During a survey around the Hawaiian Islands, minke whales were identified as the source of the mysterious “boing” sound of the north Pacific Ocean, specifically offshore of Kauai and closer in, near the PMRF, Barking Sands region (Barlow et al., 2004; Rankin and Barlow, 2005). This new information has allowed acoustical detection of minke whales, although they are rarely observed during visual surveys (Barlow, 2006; Barlow et al., 2004; Rankin et al., 2007). Recent research using a survey vessel’s towed acoustic array and the Navy’s hydrophones off Kauai in 2009–2010 (35 days total) provided bearings to 1,975 minke whale “boing” vocalizations located within the instrumented range offshore of the PMRF (U.S. Department of the Navy, 2011).

Open Ocean. These whales generally participate in annual migrations between low-latitude breeding grounds in the winter and high-latitude feeding grounds in the summer (Kuker et al., 2005). Minke whales generally occupy waters over the continental shelf, including inshore bays, and even occasionally enter estuaries. However, records from whaling catches and research surveys worldwide indicate an open ocean component to the minke whale’s habitat. The migration paths of the minke whale include travel between breeding to feeding grounds and have been shown to follow patterns of prey availability (Jefferson et al., 2015).

Population and Abundance

There currently is no population estimate for the Hawaii stock of minke whale, which appears to occur seasonally (about October to April) around the Hawaiian Islands. During summer/fall shipboard surveys of the Hawaiian Islands EEZ in 2002 and 2010 (Barlow, 2003; Bradford et al., 2013), one individual was sighted in each year. However, the majority of individuals would typically be expected to be located farther north at this time of year.

Predator/Prey Interactions

This species preys on small invertebrates and schooling fish, such as sand eel, pollock, herring, and cod. Similar to other rorquals, minke whales are lunge feeders, often plunging through patches of shoaling fish or krill (Hoelzel et al., 1989; Jefferson et al., 2015). In the north Pacific, major foods include small invertebrates, krill, capelin, herring, pollock, haddock, and other small shoaling fish (Jefferson et al., 2015; Kuker et al., 2005; Lindstrom and Haug, 2001). Minke whales are prey for killer whales (Ford et al., 2005); a minke was observed being attacked by killer whales near British Columbia (Weller, 2008).

Species-Specific Threats

Serious injury or mortality from interactions with fishing gear poses a threat to minke whales.

4.7 Sperm Whale (*Physeter macrocephalus*)

The sperm whale is the only large whale that is an odontocete (toothed whale).

Status and Management

The sperm whale has been listed as endangered since 1970 under the precursor to the ESA and is depleted under the MMPA. Sperm whales are divided into three stocks in the Pacific. Of these, the Hawaii stock occurs within the Study Area.

Geographic Range and Distribution

General. The sperm whale occurs in all oceans, ranging from the pack ice in both hemispheres to the equator. Primarily, this species is typically found in the temperate and tropical waters of the Pacific (Rice, 1989). This species appears to have a preference for deep waters (Jefferson et al., 2015). Typically, sperm whale concentrations correlate with areas of high productivity, including areas near drop-offs and with strong currents and steep topography (Gannier and Praca, 2007; Jefferson et al., 2015).

Insular Pacific-Hawaiian Large Marine Ecosystem. Sperm whales occur in Hawaii waters and are one of the more abundant large whales found in that region (Baird, McSweeney, et al., 2003; Mobley et al., 2000).

Open Ocean. Sperm whales show a strong preference for deep waters (Rice, 1989; Whitehead, 2003). Their distribution is typically associated with waters over the continental shelf break, over the continental slope, and into deeper waters.

Sperm whales are somewhat migratory. General shifts occur during summer months for feeding and breeding, while in some tropical areas, sperm whales appear to be largely resident (Rice, 1989; Whitehead, 2003; Whitehead et al., 2008). Pods of females with calves remain on breeding grounds throughout the year, between 40° N and 45° N (Rice, 1989; Whitehead, 2003), while males migrate between low-latitude breeding areas and higher-latitude feeding grounds (Pierce et al., 2007). In the northern hemisphere, "bachelor" groups (males typically 15 to 21 years old and bulls [males] not taking part in reproduction) generally leave warm waters at the beginning of summer and migrate to feeding grounds that may extend as far north as the perimeter of the arctic zone. In fall and winter, most return south, although some may remain in the colder northern waters during most of the year (Pierce et al., 2007).

Population and Abundance

The abundance of sperm whales in the eastern tropical Pacific has been estimated as 22,700 individuals. The current best available abundance estimate for the Hawaii stock of sperm whales is 3,354 (CV = 0.34). Sperm whales are frequently identified via visual observation and hydrophones on the PMRF range (U.S. Department of the Navy, 2015).

Predator/Prey Interactions

Sperm whales are known to occur in groups for both predator defense and foraging purposes. Sperm whales feed on squid, other cephalopods, and bottom-dwelling fish and invertebrates (Davis et al., 2007; Marcoux et al., 2007; Rice, 1989). Exactly how sperm whales search for, detect, and capture their prey remains uncertain. False killer whales, pilot whales, and killer whales have been documented harassing and, on occasion, attacking sperm whales (Baird, 2009a).

Species-Specific Threats

Sperm whales are susceptible to entanglement in fishing gear, ingestion of marine debris, and ship strikes.

4.8 Pygmy Sperm Whale (*Kogia breviceps*)

There are two species of *Kogia*: the pygmy sperm whale (*Kogia breviceps*) and the dwarf sperm whale (*Kogia sima*). Before 1966 they were considered to be the same species until morphological distinction was shown (Handley, 1966). Dwarf and pygmy sperm whales are difficult to distinguish from one another at sea, and many misidentifications have been made. Sightings of either species are often categorized as the genus *Kogia* (Jefferson et al., 2015).

Status and Management

The pygmy sperm whale is protected under the MMPA but is not listed under the ESA. Two stocks are identified in the Pacific Ocean. Of these, only the Hawaii stock occurs in the Study Area.

Geographic Range and Distribution

General. Pygmy sperm whales apparently occur close to shore, sometimes over the outer continental shelf. However, several studies have suggested that this species generally occurs beyond the continental shelf edge (Bloodworth and Odell, 2008; MacLeod et al., 2004). The pygmy sperm whale frequents more temperate habitats than the other *Kogia* species, which is more of a tropical species.

Insular Pacific-Hawaiian Large Marine Ecosystem. Sightings of pygmy sperm whales are rarely reported in Hawaii. During boat surveys between 2000 and 2003 in the Main Hawaiian Islands, this species was observed but less commonly than the dwarf sperm whale (Baird, 2005; Baird, McSweeney, et al., 2003; Barlow et al., 2004). A freshly dead specimen was observed about 100 NM north of French Frigate Shoals during a 2010 survey. Pygmy sperm whales are one of the more commonly stranded species in the Hawaiian Islands, and this frequency of strandings indicates that the species is likely more common than sightings suggest (Maldini et al., 2005).

Open Ocean. Although deep oceanic waters may be the primary habitat for pygmy sperm whales, very few oceanic sightings offshore have been recorded within the Study Area. However, this may be because of the difficulty of detecting and identifying these animals at sea (Caldwell and Caldwell, 1989; Maldini et al., 2005). Records of this species from both the western (Japan) and eastern Pacific (California) suggest that the range of this species includes the North Pacific Central Gyre, and North Pacific Transition Zone (Carretta et al., 2010; Jefferson et al., 2015; Katsumata et al., 2004; Marten, 2000; Norman et al., 2004). Their range generally includes tropical and temperate warm water zones and is not likely to extend north into subarctic waters (Bloodworth and Odell, 2008; Jefferson et al., 2015).

Little is known about possible migrations of this species. No specific information regarding routes, seasons, or resighting rates in specific areas is available.

Population and Abundance

Few abundance estimates have been made for this species. Previously, based on results of a 2002 shipboard line-transect survey of the entire Hawaiian Islands EEZ, abundance was estimated as 7,138 individuals. However, NMFS no longer considers this information valid because it is out of date. There is no abundance estimate currently available. The frequency of strandings suggests pygmy sperm whales may not be as uncommon as sightings would suggest (Jefferson et al., 2015; Maldini et al., 2005).

Predator/Prey Interactions

Pygmy sperm whales feed on cephalopods and, less often, on deep-sea fishes and shrimps (Beatson, 2007; Caldwell and Caldwell, 1989). A recent study in Hawaiian waters showed cephalopods were the primary prey of pygmy sperm whales, making up 78.7 percent of prey abundance and 93.4 percent contribution by mass (West et al., 2009). Stomach samples revealed an extreme diversity of cephalopod prey, with 38 species from 17 different families (West et al., 2009). Pygmy sperm whales have not been documented to be prey to any other species although, similar to other whale species, they are likely subject to occasional killer whale predation.

Species-Specific Threats

Pygmy sperm whales are susceptible to fisheries interactions.

4.9 Dwarf Sperm Whale (*Kogia sima*)

There are two species of *Kogia*, the pygmy sperm whale and the dwarf sperm whale, which had been considered to be the same species until recently. Genetic evidence suggests that there might also be two separate species of dwarf sperm whales globally, one in the Atlantic and one in the Indo-Pacific (Jefferson et al., 2015). Dwarf and pygmy sperm whales are difficult to distinguish from one another at sea, and many misidentifications have been made. Sightings of either species are often categorized as the genus *Kogia* (Jefferson et al., 2015).

Status and Management

The dwarf sperm whale is protected under the MMPA and is not listed under the ESA. NMFS has designated two stocks of dwarf sperm whales in the Pacific Ocean. Of these, the Hawaii stock occurs in the Study Area.

Geographic Range and Distribution

General. Dwarf sperm whales tend to occur over the outer continental shelf, and they may be relatively coastal in some areas with deep waters nearshore (MacLeod et al., 2004). Although the dwarf sperm whale appears to prefer more tropical waters than the pygmy sperm whale, the exact habitat preferences of the species are not well understood. Dwarf sperm whales have been observed in both outer continental shelf and more oceanic waters. Records of this species from both the western Pacific (Taiwan) and eastern Pacific (California) suggest that its range includes the southern portions of the California Current Large Marine Ecosystem, all waters of the North Pacific Central Gyre, the Insular Pacific-Hawaiian Large Marine Ecosystem, and the southern portion of the North Pacific Transition Zone (Carretta et al., 2010; Jefferson et al., 2015; Wang and Yang, 2006; Wang et al., 2001).

Insular Pacific-Hawaiian Large Marine Ecosystem. During vessel surveys between 2000 and 2003 in the Main Hawaiian Islands, this species was the sixth most commonly observed species, typically in deep water (down to 10,400 feet [3,169.9 m]) (Baird, 2005; Baird, McSweeney, et al., 2003; Barlow et al., 2004). Small boat surveys within the Main Hawaiian Islands since 2002 have documented dwarf sperm whales on 73 occasions, most commonly in water depths between 500 m and 1,000 m (Baird et al., 2013). Dwarf sperm whales are one of the more commonly stranded species in the Hawaiian Islands (Maldini et al., 2005), and the frequency of strandings indicates that the species is likely more common than sightings suggest.

Open Ocean. Although deep oceanic waters may be the primary habitat for this species, very few oceanic sightings offshore have occurred within the Study Area. The lack of sightings may be due to the difficulty of detecting and identifying these animals at sea (Jefferson et al., 2015; Maldini et al., 2005).

Population and Abundance

Results of a 2002 shipboard line-transect survey of the entire Hawaiian Islands EEZ indicated an abundance of 17,519 individuals. However, NMFS considers this information to be out of date and no longer valid. Accordingly, there is no abundance estimate currently available. The frequency of strandings suggests that dwarf sperm whales may not be as uncommon as sightings would suggest (Jefferson et al., 2015).

Predator/Prey Interactions

Dwarf sperm whales feed on cephalopods and, less often, on deep sea fishes and shrimps (Caldwell and Caldwell, 1989; Sekiguchi et al., 1992). Dwarf sperm whales generally forage near the seafloor (McAlpine, 2009). Killer whales are predators of dwarf sperm whales (Dunphy-Daly et al., 2008).

Species-Specific Threats

There are no significant species-specific threats to dwarf sperm whales in the Study Area.

4.10 Killer Whale (*Orcinus orca*)

A single species of killer whale is currently recognized, but genetic and morphological evidence has led some cetacean biologists to consider the possibility of multiple species or subspecies worldwide. In the north Pacific, these forms are variously known as ‘‘residents,’’ ‘‘transients,” and “offshore” ecotypes (Hoelzel et al., 2007).

Status and Management

The killer whale is protected under the MMPA, and overall the species is not listed under the ESA (the southern resident population in Puget Sound, not found in the Study Area, is listed as endangered under the ESA and depleted under the MMPA). The AT1 transient stock is also depleted under the MMPA. In the Pacific Ocean, NMFS recognizes the AT1 Transient stock, four Eastern North Pacific stocks, the West Coast Transient stock, the Eastern North Pacific Offshore stock, and a Hawaii stock (Carretta et al., 2015). Only the Hawaii stock occurs in the Study Area.

Geographic Range and Distribution

General. Killer whales are found in all marine habitats from the coastal zone (including most bays and inshore channels) to deep oceanic basins and from equatorial regions to the polar pack ice zones of both hemispheres. Although killer whales are also found in tropical waters and the open ocean, they are most numerous in coastal waters and at higher latitudes (Dahlheim and Heyning, 1999). The range of this species is known to include the Insular Pacific-Hawaiian Large Marine Ecosystem, the North Pacific Gyre, and North Pacific Transition Zone.

Insular Pacific-Hawaiian Large Marine Ecosystem. Although killer whales apparently prefer cooler waters, they have been observed in Hawaiian waters (Barlow, 2006; Shallenberger, 1981). Sightings are extremely infrequent in Hawaiian waters and typically occur during winter, suggesting those sighted are seasonal migrants (Baird, Hanson, et al., 2003; Mobley, Mazzuca, et al., 2001). Baird (2006) documented 21 sightings of killer whales within the Hawaiian Islands EEZ, primarily around the Main Hawaiian Islands. Summer/fall surveys of the Hawaiian Islands EEZ resulted in one sighting (Bradford et al., 2013). Killer whales are occasionally sighted off Kauai (e.g., Cascadia Research, 2012a). There are also documented strandings for this species from the Hawaiian Islands (Maldini et al., 2005).

Open Ocean. This species is known to occur in deep oceanic waters off Hawaii and elsewhere in the Pacific (Carretta et al., 2010; Miyashita et al., 1996; Wang et al., 2001). In the eastern tropical Pacific, killer whales are known to occur from offshore waters of San Diego to Hawaii and south to Peru (Barlow, 2006; Ferguson, 2005). Offshore killer whales are known to inhabit both the western and eastern temperate Pacific and likely have a continuous distribution across the north Pacific (Steiger et al., 2008).

In most areas of their range, killer whales do not show movement patterns that would be classified as traditional migrations. However, there are often seasonal shifts in density, both onshore/offshore and north/south.

Population and Abundance

The current best available abundance estimate for the Hawaii stock, based on a 2010 shipboard survey of the entire Hawaiian Islands EEZ, is 101 (CV = 1.00) killer whales.

Predator/Prey Interactions

Killer whales feed on a variety of prey, including bony fishes, elasmobranchs (a class of fish composed of sharks, skates, and rays), cephalopods, seabirds, sea turtles, and other marine mammals (Fertl et al., 1996;

Jefferson et al., 2015). Some populations are known to specialize in specific types of prey (Jefferson et al., 2015; Krahn et al., 2004; Wade et al., 2009). The killer whale has no known natural predators; it is considered to be the top predator of the oceans (Ford, 2008).

Species-Specific Threats

Boat traffic has been shown to affect the behavior of the endangered southern resident killer whale population around San Juan Island, Washington (Lusseau et al., 2009). In the presence of boats, whales were significantly less likely to be foraging and significantly more likely to be traveling (Lusseau et al., 2009). These changes in behavior were particularly evident when boats were within 330 feet (100 m) of the whales. While this population of killer whales is not present in the Study Area, their behavior may be indicative of other killer whale populations that are present.

Another issue that has been recognized as a potential threat to the endangered southern resident killer whale population is the potential reduction in prey, particularly Chinook salmon (Ford et al., 2009). As noted above, while this population of killer whales is not present in the Study Area, prey reduction may be a threat to other killer whale populations as well. Additionally, killer whales may be particularly susceptible to interactions with fisheries including entanglement.

4.11 False Killer Whale (*Pseudorca crassidens*)

Status and Management

Not much is known about most false killer whale populations globally, but the species is known to be present in Hawaiian waters. NMFS currently recognizes a Hawaiian Islands Stock Complex, which includes the Hawaii Pelagic stock, the Northwestern Hawaiian Islands stock, and the Main Hawaiian Islands insular stock. All stocks of false killer whales are protected under the MMPA. The Main Hawaiian Islands insular stock (considered resident to the Main Hawaiian Islands consisting of Kauai, Oahu, Molokai, Lanai, Kahoolawe, Maui, and Hawaii) is listed as endangered under the ESA and as depleted under the MMPA. The historical decline of this stock has been the result of various factors, including small population size, evidence of decline of the local Hawaii stock, and incidental take by commercial fisheries (Oleson et al., 2010). It is estimated that approximately eight false killer whales from the Main Hawaiian Islands insular and Hawaii Pelagic stocks are killed or seriously injured by commercial longline fisheries each year (McCracken and Forney, 2010). This number is most likely an underestimate since it does not include any animals that were unidentified and might have been false killer whales. Due to evidence of a serious decline in the population (Reeves et al., 2009), a Take Reduction Team (a team of experts to study the specific topic, also referred to as a Biological Reduction Team) was formed by NOAA in 2010 as required by the MMPA. As a result of the Take Reduction Team's activities, a Take Reduction Plan was published in 2012. The plan identifies regulatory and non-regulatory measures designed to reduce mortalities and serious injuries of false killer whales that are associated with Hawaii long-line fisheries.

The NMFS considers all false killer whales found within 72 km (39 NM) of each of the Main Hawaiian Islands as part of the Main Hawaiian Islands Insular stock. In the vicinity of the Main Hawaiian Islands, the Hawaii Pelagic stock is considered to inhabit waters greater than 11 km (6 NM) from shore. There is no inner boundary for the Hawaii Pelagic stock within the Northwestern Hawaiian Islands. Animals belonging to the Northwestern Hawaiian Islands stock are considered to inhabit waters within a 93 km (50 NM) radius of the Northwestern Hawaiian Islands, or the boundary of the Papahānaumokuākea Marine National Monument, with the radial boundary extended to the southeast to encompass Kauai and Niihau. NMFS recognizes that there is geographic overlap between the stocks in some areas. In particular, individuals from the Northwestern Hawaiian Islands and Hawaii Pelagic stocks have potential for occurrence at the Long Range Strike WSEP impact location. This overlap precludes analysis of differential impact between the two stocks based on spatial criteria.

The density data used in the Navy's modeling and analyses were derived from habitat-based density models for the combined stocks, since limited sighting data did not allow for stock-specific models (Becker et al., 2012). Habitat-based density models allow predictions of cetacean densities on a finer spatial scale than traditional analyses (Barlow et al., 2009) and are thus better suited for spatially explicit effects analyses. In the most recent draft stock assessment report (Carretta et al., 2015), separate abundance numbers are provided for each stock of the false killer whale Hawaiian Islands Stock Complex.

Geographic Range and Distribution

General. The range of this species is known to include waters of the Insular Pacific-Hawaiian Large Marine Ecosystems and the North Pacific Gyre.

Insular Pacific-Hawaiian Large Marine Ecosystem. The false killer whale is regularly found within Hawaiian waters and has been reported in groups of up to 100 (Shallenberger, 1981; Baird, Hanson, et al., 2003). A handful of stranding records exists in the Hawaiian Islands (Maldini et al., 2005). Distribution of Main Hawaiian Islands insular false killer whales has been assessed using data from visual surveys and satellite tag data. Tagging data from seven groups of individuals tagged off the islands of Hawaii and Oahu indicate that the whales move rapidly and semi-regularly throughout the Main Hawaiian Islands and have been documented as far as 112 km offshore over a total range of 31,969 square miles (mi^2) (82,800 square kilometers [km^2]) (Baird et al., 2012). Baird et al. (2012) note, however, that limitations in the sampling "suggest the range of the population is likely underestimated, and there are probably other high-use areas that have not been identified." Photo-identification studies also document that the animals regularly use both leeward and windward sides of the islands (Baird et al., 2005a; Baird, 2009a; Baird et al., 2010a; Forney et al., 2010; Baird et al., 2012). Some individual false killer whales tagged off the island of Hawaii have remained around that island for extended periods (days to weeks), but individuals from all tagged groups eventually were found broadly distributed throughout the Main Hawaiian Islands (Baird, 2009a; Forney et al., 2010). Individuals utilize habitat over varying water depths from less than 164 feet (50 m) to greater than 13,123 feet (4,000 m) (Baird et al., 2010a). It has been hypothesized that interisland movements may depend on the density and movement patterns of their prey species (Baird, 2009a).

Open Ocean. In the north Pacific, this species is known to occur in deep oceanic waters off Hawaii and elsewhere in the Pacific (Carretta et al., 2010; Miyashita et al., 1996; Wang et al., 2001). False killer whales are not considered a migratory species, although seasonal shifts in density likely occur. Seasonal movements in the western north Pacific may be related to prey distribution (Odell and McClune, 1999). Satellite-tracked individuals around the Hawaiian Islands indicate that false killer whales can move extensively among different islands and also sometimes move from an island coast to as far as 60 miles. (96.6 km) offshore (Baird, 2009a; Baird et al., 2010a).

Population and Abundance

False killer whales found in waters surrounding the Main Hawaiian Islands are known to be genetically separate from the population in the outer part of the Hawaiian Islands EEZ and the central tropical Pacific (Chivers et al., 2007; Reeves et al., 2009). Recent genetic research by Chivers et al. (2010) indicates that the Main Hawaiian Islands insular and Hawaii Pelagic populations of false killer whales are independent and do not interbreed. The current abundance estimate of the Main Hawaiian Islands insular stock is 151 individuals (CV = 0.20), the Hawaii Pelagic stock is 1,540 individuals (CV = 0.66), and the Northwestern Hawaiian Islands stock is 617 individuals (CV = 1.11).

Reeves et al. (2009) summarized information on false killer whale sightings near Hawaii between 1989 and 2007, based on various survey methods, and suggested that the Main Hawaiian Islands stock may have declined during the last two decades. Baird (2009a) reviewed trends in sighting rates of false killer whales from aerial surveys conducted using consistent methodology around the Main Hawaiian Islands between 1994 and 2003. Sighting rates during these surveys exhibited a significant decline that could not be attributed to any weather or methodological changes. Data are currently insufficient to determine population trends for the Northwestern Hawaiian Islands or Hawaii Pelagic stocks (Carretta et al., 2015).

Predator/Prey Interactions

False killer whales feed primarily on deep-sea cephalopods and fish (Odell and McClune, 1999). They may prefer large fish species, such as mahi mahi and tunas. Twenty-five false killer whales that stranded off the coast of the Strait of Magellan were examined and found to feed primarily on cephalopods and fish. Squid beaks were found in nearly half of the stranded animals. The most important prey species were found to be the squid species *Martialiabyadesi* and *Illex argentinus* followed by the coastal fish, *Macruronus magellanicus* (Alonso et al., 1999). False killer whales have been observed to attack other cetaceans, including dolphins and large whales such as humpback and sperm whales (Baird, 2009b). They are known to behave aggressively toward small cetaceans in tuna purse seine nets. Unlike other whales or dolphins, false killer whales frequently pass prey back and forth among individuals before they start to eat the fish, in what appears to be a way of affirming social bonds (Baird et al., 2010a). This species is believed to be preyed on by large sharks and killer whales (Baird, 2009b). Like many marine mammals, false killer whales accumulate high levels of toxins in their blubber over the course of their long lives. Because they feed on large prey at the top of the food chain (e.g., squid, tunas) they may be impacted by competition with fisheries (Cascadia Research, 2010).

Species-Specific Threats

In Hawaiian waters, false killer whales are particularly susceptible to fishery interactions and entanglements (Forney et al., 2010).

4.12 Pygmy Killer Whale (*Feresa attenuata*)

The pygmy killer whale is often confused with the false killer whale and melon-headed whale, which are similar in overall appearance.

Status and Management

The pygmy killer whale is protected under the MMPA and is not listed under the ESA. For the MMPA stock assessment reports, there is a single Pacific management stock including animals found within the Hawaiian Islands EEZ and in adjacent high seas waters. However, due to lack of data regarding abundance, distribution, and impacts for high seas waters, the status of the stock is evaluated based only on occurrence in waters of the Hawaiian Islands EEZ.

Geographic Range and Distribution

General. The pygmy killer whale is generally an open ocean deepwater species (Davis et al., 2000; Wursig et al., 2000).

Insular Pacific-Hawaiian Large Marine Ecosystem. Although rarely seen in nearshore waters, sightings have been relatively frequent in the Insular Pacific-Hawaiian Large Marine Ecosystem (Barlow et al., 2004; Donahue and Perryman, 2008; Pryor et al., 1965; Shallenberger, 1981; Smultea et al., 2007). A line-transect survey conducted in February 2009 by the Cetacean Research Program surrounding the Hawaiian Islands resulted in the sighting of one pygmy killer whale (Oleson and Hill, 2009). Shipboard surveys in the Hawaiian Islands EEZ in 2002 and 2010 resulted in a total of eight additional sightings (Barlow, 2006; Bradford et al., 2013). Six strandings have been documented from Maui and the Island of Hawaii (Carretta et al., 2010; Maldini et al., 2005).

Open Ocean. This species' range in the open ocean generally extends to the southern regions of the North Pacific Gyre and the southern portions of the North Pacific Transition Zone. Many sightings have occurred from cetacean surveys of the eastern tropical Pacific (Au and Perryman, 1985; Barlow and

Gisiner, 2006; Wade and Gerrodette, 1993). This species is also known to be present in the western Pacific (Wang and Yang, 2006). Its range is generally considered to be south of 40° N and continuous across the Pacific (Donahue and Perryman, 2008; Jefferson et al., 2015). Migrations or seasonal movements are not known.

Population and Abundance

Although the pygmy killer whale has an extensive global distribution, it is not known to occur in high densities in any region and thus is probably one of the least abundant of the pantropical delphinids. The current best available abundance estimate for the pygmy killer whale derives from a 2010 shipboard survey of the Hawaiian Islands EEZ; the estimate was 3,433 individuals (CV = 0.52) (Bradford et al., 2013).

Predator/Prey Interactions

Pygmy killer whales feed predominantly on fish and squid. They have been known to attack other dolphin species, apparently as prey, although this is not common (Jefferson et al., 2015; Perryman and Foster, 1980; Ross and Leatherwood, 1994). The pygmy killer whale has no documented predators (Weller, 2008). However, like other cetaceans, it may be subject to predation by killer whales.

Species-Specific Threats

Fisheries interactions are likely as evidenced by a pygmy killer whale that stranded on Oahu with signs of hooking injury (NMFS, 2007a) and the report of mouthline injuries noted in some individuals (Baird unpublished data cited in Carretta et al., 2011). It has been suggested that pygmy killer whales may be particularly susceptible to loud underwater sounds, such as active sonar and seismic operations, based on the stranding of pygmy killer whales in Taiwan (Wang and Yang, 2006). However, this suggestion is probably not supported by the data available.

4.13 Short-Finned Pilot Whale (*Globicephala macrorhynchus*)

Status and Management

Short-finned pilot whales are protected under the MMPA and are not listed under the ESA. For MMPA stock assessment reports, short-finned pilot whales within the Pacific U.S. EEZ are divided into two discrete areas: (1) waters off California, Oregon, and Washington and (2) Hawaiian waters. The short-finned pilot whale is widely distributed throughout most tropical and warm temperate waters of the world.

Geographic Range and Distribution

General. A number of studies in different regions suggest that the distribution and seasonal inshore/offshore movements of pilot whales coincide closely with the abundance of squid, their preferred prey (Bernard and Reilly, 1999; Hui, 1985; Payne and Heinemann, 1993). This species' range generally extends to the southern regions of the North Pacific Gyre and the California Current and Insular Pacific-Hawaiian Large Marine Ecosystems. Many sightings have occurred from cetacean surveys of the eastern tropical Pacific, where the species is reasonably common (Au and Perryman, 1985; Barlow, 2006; Wade and Gerrodette, 1993).

Insular Pacific-Hawaiian Large Marine Ecosystem. Short-finned pilot whales are known to occur in waters surrounding the Hawaiian Islands (Barlow, 2006; Shallenberger, 1981; Smultea et al., 2007). They are most commonly observed around the Main Hawaiian Islands, are relatively abundant around Oahu and the Island of Hawaii, and are also present around the Northwestern Hawaiian Islands (Barlow, 2006; Maldini Feinholz, 2003; Shallenberger, 1981). Fourteen strandings of this species have been recorded at the Main Hawaiian Islands, including five mass strandings (Carretta et al., 2010; Maldini et al., 2005). Short-finned pilot whales were detected in nearshore waters off the western shore of Kauai during passive acoustic and visual surveys in 2014.

Open Ocean. The short-finned pilot whale occurs mainly in deep offshore areas; thus, the species occupies waters over the continental shelf break, in slope waters, and in areas of high topographic relief (Olson, 2009). While pilot whales are typically distributed along the continental shelf break, movements over the continental shelf are commonly observed in the northeastern United States (Payne and Heinemann, 1993) and close to shore at oceanic islands, where the shelf is narrow and deeper waters are found nearby (Gannier, 2000; Mignucci-Giannoni, 1998). Short-finned pilot whales are not considered a migratory species, although seasonal shifts in abundance have been noted in some portions of the species' range.

Population and Abundance

A 2010 shipboard survey of the entire Hawaiian Islands EEZ resulted in an abundance estimate of 12,422 (CV = 0.43) short-finned pilot whales and is considered to be the best available estimate (Bradford et al., 2013).

Predator/Prey Interactions

Pilot whales feed primarily on squid but also take fish (Bernard and Reilly, 1999). They are generally well adapted to feeding on squid (Jefferson et al., 2015; Werth, 2006a; Werth, 2006b). Pilot whales are not generally known to prey on other marine mammals, but records from the eastern tropical Pacific suggest that the short-finned pilot whale does occasionally chase and attack, and may eat, dolphins during fishery operations (Olson, 2009; Perryman and Foster, 1980). They have also been observed harassing sperm whales in the Gulf of Mexico (Weller et al., 1996).

This species is not known to have any predators (Weller, 2008). It may be subject to predation by killer whales.

Species-Specific Threats

Short-finned pilot whales are particularly susceptible to fisheries interactions and entanglement.

4.14 Melon-Headed Whale (*Peponocephala electra*)

This small tropical dolphin species is similar in appearance to the pygmy killer whale.

Status and Management

The melon-headed whale is protected under the MMPA and is not listed under the ESA. NMFS has identified a Hawaiian Islands Stock Complex, which consists of Hawaiian Islands and Kohala Resident stocks. The Kohala resident stock includes melon-headed whales off the Kohala Peninsula and west coast of Hawaii Island, in waters less than 2,500 m depth. These whales would not be expected in the Study Area. The Hawaiian Islands stock includes whales occurring throughout the Hawaiian Islands EEZ (including the area of the Kohala resident stock) and adjacent high seas waters. Due to a lack of data, stock evaluation is based on whales in the Hawaiian Islands EEZ only. In addition, in the area of overlap between the two stocks, individual animals can currently only be distinguished by photographic identification.

Geographic Range and Distribution

General. Melon-headed whales are found worldwide in tropical and subtropical waters. They have occasionally been reported at higher latitudes, but these movements are considered to be beyond their normal range because the records indicate these movements occurred during incursions of warm water currents (Perryman et al., 1994). The range of this species is known to include waters of the Insular Pacific-Hawaiian Large Marine Ecosystems and the North Pacific Gyre (Jefferson et al., 2015; Perryman, 2008). In the north Pacific, occurrence of this species is well known in deep waters off many areas, including Hawaii (Au and Perryman, 1985; Carretta et al., 2010; Ferguson, 2005; Perrin, 1976; Wang et al., 2001).

Insular Pacific-Hawaiian Large Marine Ecosystem. The melon-headed whale is regularly found within Hawaiian waters (Baird, Hanson, et al., 2003; Baird, McSweeney, et al., 2003; Mobley et al., 2000; Shallenberger, 1981). Large groups are seen regularly, especially off the Waianae coast of Oahu, the north Kohala coast of Hawaii, and the leeward coast of Lanai (Baird, 2006; Shallenberger, 1981). A line-transect survey conducted in February 2009 by the Cetacean Research Program surrounding the Hawaiian Islands resulted in the sighting of one melon-headed whale (Oleson and Hill, 2009). Similarly, a shipboard survey of the entire Hawaiian Islands EEZ in 2010 resulted in one sighting (Bradford et al., 2013). A total of 14 stranding records exist for this species in the Hawaiian Islands (Carretta et al., 2010; Maldini et al., 2005).

Open Ocean. Melon-headed whales are most often found in offshore deep waters but sometimes move close to shore over the continental shelf. Brownell et al. (2009) found that melon-headed whales near oceanic islands rest near shore during the day and feed in deeper waters at night. The melon-headed whale is not known to migrate.

Population and Abundance

As described in the most recent stock assessment report (Carretta et al., 2015), the current best available abundance estimate for the Hawaiian Islands stock of melon-headed whale is 5,794 (CV = 0.20). The abundance estimate for the Kohala resident stock is 447 individuals (CV = 0.12).

Predator/Prey Interactions

Melon-headed whales prey on squid, pelagic fishes, and occasionally crustaceans. Most of the fish and squid families eaten by this species consist of mid-water forms found in waters to 4,920 feet (1,500 m) deep, suggesting that feeding takes place deep in the water column (Jefferson and Barros, 1997). Melon-headed whales are believed to be preyed on by killer whales and have been observed fleeing from killer whales in Hawaiian waters (Baird et al., 2006a).

Species-Specific Threats

There are no significant species-specific threats to melon-headed whales in Hawaii, although it is likely that they are susceptible to fisheries interactions.

4.15 Bottlenose Dolphin (*Tursiops truncatus*)

The classification of the genus *Tursiops* continues to be in question; two species are recognized, the common bottlenose dolphin (*Tursiops truncatus*) and the Indo-Pacific bottlenose dolphin (*Tursiops aduncus*) (Rice, 1998), though additional species are likely to be recognized with future analyses (Natoli et al., 2004).

Status and Management

The bottlenose dolphin is protected under the MMPA and is not listed under the ESA. For the MMPA stock assessment reports, multiple bottlenose dolphin stocks are designated within the Pacific U.S. EEZ. However, within the region of the Study Area, NMFS has identified five stocks that compose the bottlenose dolphin Hawaiian Islands Stock Complex: (1) Hawaii Pelagic, (2) Kauai/ Niihau, (3) Oahu, (4) the 4-Island region, and (5) Hawaii Island. The most recent stock assessment report (Carretta et al., 2015) indicates that demographically independent populations likely exist in the Northwestern Hawaiian Islands. However, data are currently insufficient to delineate such stocks, and bottlenose dolphins in this portion of Hawaii are included in the Hawaii Pelagic stock (Carretta et al., 2015).

Geographic Range and Distribution

General. Common bottlenose dolphins are found most commonly in coastal and continental shelf waters of tropical and temperate regions of the world. They occur in most enclosed or semi-enclosed seas. The species inhabits shallow, murky, estuarine waters and also deep, clear offshore waters in oceanic regions

(Jefferson et al., 2015; Wells et al., 2009). Common bottlenose dolphins are often found in bays, lagoons, channels, and river mouths and are known to occur in very deep waters of some ocean regions. The range of this species is known to include waters of the Insular Pacific-Hawaiian Large Marine Ecosystems, the North Pacific Gyre, and the North Pacific Transition Zone (Au and Perryman, 1985; Carretta et al., 2010; Miyashita, 1993; Wang and Yang, 2006).

Insular Pacific-Hawaiian Large Marine Ecosystem. Common bottlenose dolphins are common throughout the Hawaiian Islands, and they are typically observed throughout the main islands and from the Island of Hawaii to Kure Atoll within 5 miles (8.05 km) of the coast (Baird et al., 2009a; Shallenberger, 1981). In the Hawaiian Islands, this species is found in both shallow coastal waters and deep offshore waters (Baird, McSweeney, et al., 2003). The offshore variety is typically larger than the inshore. Twelve stranding records from the Main Hawaiian Islands exist (Maldini et al., 2005; Maldini Feinholz, 2003). Common bottlenose dolphin vocalizations have been documented during acoustic surveys, and the species has been commonly sighted during aerial surveys in the Hawaiian Islands (Barlow et al., 2008; Barlow et al., 2004; Mobley et al., 2000). Bottlenose dolphins were detected in nearshore waters off the western shore of Kauai during passive acoustic and visual surveys in 2014.

Open Ocean. In the eastern tropical Pacific and elsewhere, open ocean populations occur far from land. However, population density appears to be higher in nearshore areas (Scott and Chivers, 1990). In the north Pacific, common bottlenose dolphins have been documented in offshore waters as far north as about 41° N (Carretta et al., 2010). Although in most areas bottlenose dolphins do not migrate (especially where they occur in bays, sounds, and estuaries), seasonal shifts in abundance do occur in many areas (Griffin and Griffin, 2004).

Population and Abundance

The current best available abundance estimate of the Hawaiian Islands Stock Complex of common bottlenose dolphins comes from a ship survey of the entire Hawaiian Islands EEZ in 2010 (Bradford et al., 2013). The resulting abundance estimates for the various stocks are as follows: (1) Hawaii Pelagic - 5,794 individuals (CV = 0.59); (2) Kauai and Niihau – 147 individuals (CV = 0.11); (3) Oahu – 594 individuals (CV = 0.54); (4) 4-Island Region – 153 individuals (CV = 0.24); and (5) Hawaii Island – 102 individuals (CV = 0.13).

The criteria and thresholds developed by the Navy and NMFS result in consideration of potential impacts at distances ranging from immediately adjacent to the activity (meters) to tens of kilometers from some acoustic stressors. Therefore, the abundance estimates and generalized boundaries and locations for bottlenose dolphins stocks in Hawaii are insufficient to allow for an analysis of impacts on individual stocks, and they are treated as a group and discussed in terms of the Hawaiian Islands Stock Complex.

Predator/Prey Interactions

These animals are opportunistic feeders, taking a wide variety of fishes, cephalopods, and shrimps (Wells and Scott, 1999), and using a variety of feeding strategies (Shane, 1990). In addition to using echolocation, a process for locating prey by emitting sound waves that reflect back, bottlenose dolphins likely detect and orient to fish prey by listening for the sounds their prey produce (so-called passive listening) (Barros and Myrberg, 1987; Barros and Wells, 1998). Nearshore bottlenose dolphins prey predominantly on coastal fish and cephalopods, while offshore individuals prey on open ocean cephalopods and a large variety of near-surface and mid-water fish species (Mead and Potter, 1995). Throughout its range, this species is known to be preyed on by killer whales and sharks (Wells and Scott, 2008).

Species-Specific Threats

Common bottlenose dolphins are particularly susceptible to entanglement and other interactions with fishery operations.

4.16 Pantropical Spotted Dolphin (*Stenella attenuata*)

Status and Management

The species is protected under the MMPA and is not listed under the ESA. For the MMPA stock assessment reports, NMFS has identified four stocks that compose the pantropical spotted dolphin Hawaiian Islands Stock Complex: (1) Hawaii Pelagic, (2) Oahu, (3) the 4-Island region, and (4) Hawaii Island.

Geographic Range and Distribution

General. The pantropical spotted dolphin is distributed in offshore tropical and subtropical waters of the Pacific, Atlantic, and Indian Oceans between about 40° N and 40° S (Baldwin et al., 1999; Perrin, 2008b). The species is much more abundant in the lower latitudes of its range. It is found mostly in deeper offshore waters but does approach the coast in some areas (Jefferson et al., 2015; Perrin, 2001).

Insular Pacific-Hawaiian Large Marine Ecosystem. Based on known habitat preferences and sighting data, the primary occurrence for the pantropical spotted dolphin in the Insular Pacific-Hawaiian Large Marine Ecosystem is between 330 and 13,122 feet (100.6 to 3,999.6 m) deep. This area of primary occurrence also includes a continuous band connecting all the Main Hawaiian Islands, Nihoa, and Kaula, taking into account possible interisland movements. Secondary occurrence is expected from the shore to 330 feet (100.6 m), as well as seaward of 13,120 feet (3,998.9 m). Pantropical spotted dolphins make up a relatively large portion of odontocete sightings around Oahu, the 4-Islands, and the Island of Hawaii (about one-fourth of total sightings); however, they are largely absent from nearshore waters around Kauai and Niihau (about 4 percent of sightings) (Baird et al., 2013).

Open Ocean. In the open ocean, this species ranges from 25° N (Baja California, Mexico) to 17° south (S) (southern Peru) (Perrin and Hohn, 1994). Pantropical spotted dolphins are associated with warm tropical surface water in the eastern tropical Pacific (Au and Perryman, 1985; Reilly, 1990). Au and Perryman (1985) noted that the species occurs primarily north of the equator, off southern Mexico, and westward along 10° N.

Although pantropical spotted dolphins do not migrate, extensive movements are known in the eastern tropical Pacific (although these have not been strongly linked to seasonal changes) (Scott and Chivers, 2009).

Population and Abundance

Morphological and coloration differences and distribution patterns have been used to establish that the spotted dolphins around Hawaii belong to a stock that is distinct from those in the eastern tropical Pacific (Carretta et al., 2010). Based on shipboard surveys of the Hawaiian Islands EEZ, the current best available abundance estimate of the Hawaii Pelagic stock of the Hawaiian Islands Stock Complex is 15,917 individuals (CV = 0.40). There is currently insufficient information to provide abundance estimates for the remaining three stocks (Oahu, 4-Island Region, and Hawaii Island).

Predator/Prey Interactions

Pantropical spotted dolphins prey on near-surface fish, squid, and crustaceans and on some mid-water species (Perrin and Hohn, 1994). Results from various tracking and food habit studies suggest that pantropical spotted dolphins off Hawaii feed primarily at night on surface and mid-water species that rise with the deep scattering layer toward the water's surface after dark (Baird et al., 2001; Robertson and Chivers, 1997). Pantropical spotted dolphins may be preyed on by killer whales and sharks and have been observed fleeing killer whales in Hawaiian waters (Baird et al., 2006a). Other predators may include the pygmy killer whale, false killer whale, and occasionally the short-finned pilot whale (Perrin, 2008b).

Species-Specific Threats

Although information on fishery-related impacts to cetaceans in Hawaiian waters is limited, the gear types used result in marine mammal mortality and injury in other fisheries throughout U.S. waters, and pantropical spotted dolphins in the Hawaii region are likely impacted to some degree as well. The most recent stock assessment report (Carretta et al., 2015) describes both anecdotal and documented negative interactions with fishing activities. Pantropical spotted dolphins located in the eastern tropical Pacific have had high mortality rates associated with the tuna purse seine fishery (Wade, 1994).

4.17 Striped Dolphin (*Stenella coeruleoalba*)

Status and Management

This species is protected under the MMPA and is not listed under the ESA. In the western north Pacific, three migratory stocks are recognized. In the eastern Pacific, NMFS divides striped dolphin management stocks within the U.S. EEZ into two separate areas: waters off California, Oregon, and Washington and waters around Hawaii.

Geographic Range and Distribution

General. Although primarily a warm-water species, the range of the striped dolphin extends higher into temperate regions than those of any other species in the genus *Stenella*. Striped dolphins also are generally restricted to oceanic regions and are seen close to shore only where deep water approaches the coast. In some areas (e.g., the eastern tropical Pacific), they are mostly associated with convergence zones and regions of upwelling (Au and Perryman, 1985; Reilly, 1990). The northern limits are the Sea of Japan, Hokkaido, Washington State, and along roughly 40° N across the western and central Pacific (Reeves et al., 2002). In the eastern tropical Pacific, striped dolphins inhabit areas with large seasonal changes in surface temperature and thermocline depth, as well as seasonal upwelling (Au and Perryman, 1985; Reilly, 1990). In some areas, this species appears to avoid waters with sea temperatures less than 68° Fahrenheit (20° Celsius) (Van Waerebeek et al., 1998).

Insular Pacific-Hawaiian Large Marine Ecosystem. The striped dolphin regularly occurs around the Insular Pacific-Hawaiian Large Marine Ecosystem, although sightings are relatively infrequent there (Carretta et al., 2010). Summer/fall shipboard surveys of the Hawaiian Islands EEZ in 2002 and 2010 resulted in 15 and 29 sighting, respectively (Barlow, 2006; Bradford et al., 2013). The species occurs primarily seaward at a depth of about 547 feet (1,000 m), based on sighting records and the species' known preference for deep waters. Striped dolphins are occasionally sighted closer to shore in Hawaii, so an area of secondary occurrence is expected from a depth range of 55 to 547 feet (100 to 1,000 m). Occurrence patterns are assumed to be the same throughout the year (Mobley et al., 2000).

Open Ocean. The primary range of the striped dolphin includes the eastern and western waters of the North Pacific Transition Zone (Perrin et al., 1994a). The species is non-migratory in the Study Area.

Population and Abundance

The best available estimate of abundance for the Hawaii stock of the striped dolphin, based on the 2010 shipboard surveys described above, is 20,650 individuals (CV = 0.36).

Predator/Prey Interactions

Striped dolphins often feed in open sea or sea bottom zones along the continental slope or just beyond it in oceanic waters. Most of their prey possess light-emitting organs, suggesting that striped dolphins may be feeding at great depths, possibly diving to 655 to 2,295 feet (200 to 700 m) (Archer and Perrin, 1999). Striped dolphins may feed at night in order to take advantage of the deep scattering layer's diurnal vertical movements. Small mid-water fishes (in particular lanternfishes) and squids are the predominant prey (Perrin et al., 1994a). This species has been documented to be preyed upon by sharks (Ross, 1971). It may also be subject to predation by killer whales.

Species-Specific Threats

There are no significant species-specific threats to striped dolphins in the Study Area.

4.18 Spinner Dolphin (*Stenella longirostris*)

Six morphotypes within four subspecies of spinner dolphins have been described worldwide in tropical and warm-temperate waters, including *Stenella longirostris longirostris* (Gray's, or pantropical, spinner dolphin), *Stenella longirostris orientalis* (eastern spinner dolphin), *Stenella longirostris centroamericana* (Central American spinner dolphin), and *Stenella longirostris roseiventris* (dwarf spinner dolphin) (Perrin et al., 2009). The Gray's spinner dolphin is the most widely distributed and is the subspecies that occurs in the Study Area. Hawaiian spinner dolphins belong to a stock that is separate from animals in the eastern tropical Pacific.

Status and Management

The spinner dolphin is protected under the MMPA and the species is not listed under the ESA. Although the eastern spinner dolphin (*Stenella longirostris orientalis*) is listed as depleted under the MMPA, the Gray's spinner dolphin, which occurs in the Study Area, is not designated as depleted. NMFS has identified six stocks that compose the spinner dolphin Hawaiian Islands Stock Complex: (1) Hawaii Pelagic, (2) Hawaii Island, (3) Oahu and 4-Island, (4) Kauai and Niihau, (5) Midway Atoll/Kure, and (6) Pearl and Hermes Reef. The Hawaii Pelagic stock includes animals found both within the Hawaiian Islands EEZ (but outside of island-associated boundaries) and in adjacent international waters. Based on an analysis of individual spinner dolphin movements, no dolphins have been found farther than 10 NM from shore and few individuals move long distances (from one main Hawaiian Island to another) (Hill et al., 2011).

Geographic Range and Distribution

General. Spinner dolphins occur in both oceanic and coastal environments. Most sightings have been associated with inshore waters, islands, or banks (Perrin and Gilpatrick, 1994). Open ocean populations, such as those in the eastern tropical Pacific, often are found in waters with a shallow thermocline (rapid temperature difference with depth) (Au and Perryman, 1985; Perrin, 2008c; Reilly, 1990). The thermocline concentrates open sea organisms in and above it, which spinner dolphins feed on. In the eastern tropical Pacific, spinner dolphins are associated with tropical surface waters typified by extensive stable thermocline ridging and relatively little annual variation in surface temperature (Au and Perryman, 1985; Perrin, 2008c). Coastal populations are usually found in island archipelagos, where they are associated with coastal trophic and habitat resources (Norris and Dohl, 1980; Poole, 1995).

Insular Pacific-Hawaiian Large Marine Ecosystem. In the Hawaiian Islands, spinner dolphins occur along the leeward coasts of all the major islands and around several of the atolls northwest of the Main Hawaiian Islands. Long-term site fidelity has been noted for spinner dolphins along the Kona coast of Hawaii, and along Oahu (Marten and Psarakos, 1999; Norris et al., 1994). Navy monitoring for the Rim of the Pacific Exercise in 2006 resulted in daily sightings of spinner dolphins within the offshore area of Kekaha Beach, Kauai, near the PMRF (U.S. Department of the Navy, 2006).

Spinner dolphins occur year round throughout the Insular Pacific-Hawaiian Large Marine Ecosystem, with primary occurrence from the shore to the 13,122 feet (3,999.6 m) depth. This takes into account offshore resting habitat and offshore feeding areas. Spinner dolphins are expected to occur in shallow water resting areas (about 162 feet [49.4 m] deep or less) throughout the middle of the day, moving into deep waters offshore during the night to feed. Primary resting areas are along the west side of Hawaii, including Makako Bay, Honokohau Bay, Kailua Bay, Kealakekua Bay, Honaunau Bay, and Kauhako

Bay, and off Kahena on the southeast side of the island (Östman-Lind et al., 2004). Along the Waianae coast of Oahu, Hawaii, spinner dolphins rest along Makua Beach, Kahe Point, and Pokai Bay during the day (Lammers, 2004). Kilauea Bay on Kauai is also a popular resting bay for Hawaiian spinner dolphins (U.S. Department of the Navy, 2006). Another area of occurrence is seaward of 2,187 fathoms (4,000 m). Although sightings have been recorded around the mouth of Pearl Harbor, Hawaii, spinner dolphin occurrence is rare there (Lammers, 2004). Occurrence patterns are assumed to be the same throughout the year. Spinner dolphins were detected in nearshore waters off the western shore of Kauai during passive acoustic and visual surveys in 2014.

Open Ocean. Throughout much of their range, spinner dolphins are found in the open ocean. Spinner dolphins are pantropical, ranging through oceanic tropical and subtropical zones in both hemispheres (the range is nearly identical to that of the pantropical spotted dolphin). The primary range of Gray's spinner dolphin is known to include waters of the North Pacific Gyre and the southern waters of the North Pacific Transition Zone. Its range generally includes tropical and subtropical oceanic waters south of 40° N, continuous across the Pacific (Jefferson et al., 2015; Perrin and Gilpatrick, 1994).

Spinner dolphins are not considered a migratory species.

Population and Abundance

Hawaiian spinner dolphins belong to a separate stock than animals found in the eastern tropical Pacific. Abundance estimates are currently available for only three of the stocks composing the Hawaiian Islands Stock Complex: Hawaii Island – 790 individuals (CV = 0.17); Oahu and 4-Island – 355 individuals (CV = 0.09); and Kauai/Niihau – 601 individuals (CV = 0.20). Data are currently insufficient to calculate an abundance estimate for the remaining three stocks (Hawaii Pelagic, Midaway Atoll/Kure, and Pearl and Hermes Reef).

Predator/Prey Interactions

Spinner dolphins feed primarily on small mid-water fishes, squids, and shrimp, and they dive to at least 655 to 985 feet (200 to 300 m) (Perrin and Gilpatrick, 1994). They forage primarily at night, when the midwater community migrates toward the surface and the shore (Benoit-Bird, 2004; Benoit-Bird et al., 2001). Spinner dolphins track the horizontal migrations of their prey (Benoit-Bird and Au, 2003), allowing for foraging efficiencies (Benoit-Bird, 2004; Benoit-Bird and Au, 2003). Foraging behavior has also been linked to lunar phases in scattering layers off of Hawaii (Benoit-Bird and Au, 2004). Spinner dolphins may be preyed on by sharks, killer whales, pygmy killer whales, and short-finned pilot whales (Perrin, 2008c).

Species-Specific Threats

There are no significant species-specific threats to spinner dolphins in the Study Area.

4.19 Rough-Toothed Dolphin (*Steno bredanensis*)

Status and Management

This species is protected under the MMPA and is not listed under the ESA. Rough-toothed dolphins are among the most widely distributed species of tropical dolphins, but little information is available regarding population status (Jefferson, 2009; Jefferson et al., 2015). Genetic studies and sighting data indicate there may be at least two island-associated stocks in the Main Hawaiian Islands (Hawaii Island and Kauai/Niihau stocks). However, at this time, NMFS has designated only a single Pacific management stock including animals found within the Hawaiian Islands EEZ (Carretta et al., 2010).

Geographic Range and Distribution

General. The range of this species is known to include waters of the Insular Pacific-Hawaiian Large Marine Ecosystems and the North Pacific Gyre. This species is known to prefer deep water but has been observed in waters of various depths. At the Society Islands, rough-toothed dolphins were sighted in waters with bottom depths ranging from less than 330 feet (100 m) to more than 9,845 feet (more than 3,000 m), although they apparently favored the 1,640- to 4,920-foot (500- to 1,500-m) range (Gannier, 2000).

Insular Pacific-Hawaiian Large Marine Ecosystem. The occurrence of this species is well known in deep ocean waters off Hawaii (Baird et al., 2008; Barlow et al., 2008; Carretta et al., 2010; Pitman and Stinchcomb, 2002; Shallenberger, 1981). Rough-toothed dolphin vocalizations have been detected during acoustic surveys in the eastern tropical Pacific (Oswald et al., 2003). A ship survey in the Hawaiian Islands found that sighting rates were highest in depths greater than 4,920 feet (1,500 m) and resightings were frequent, indicating the possibility of a small population with high site fidelity (Baird et al., 2008). This species has been observed as far northwest as French Frigate Shoals (Carretta et al., 2010). Eight strandings have been reported from the Hawaiian Islands of Maui, Oahu, and Hawaii (Maldini et al., 2005). Rough-toothed dolphins were detected in nearshore waters off the western shore of Kauai during passive acoustic and visual surveys in 2014.

Open Ocean. The rough-toothed dolphin is regarded as an offshore species that prefers deep water, but it can occur in waters of variable bottom depth (Gannier and West, 2005). It rarely occurs close to land, except around islands with steep drop-offs nearshore (Gannier and West, 2005). However, in some areas, this species may frequent coastal waters and areas with shallow bottom depths (Davis et al., 1998; Fulling et al., 2003; Lodi and Hetzel, 1999; Mignucci-Giannoni, 1998; Ritter, 2002).

There is no evidence that rough-toothed dolphins migrate. No information regarding routes, seasons, or resighting rates in specific areas is available.

Population and Abundance

Based on shipboard surveys of the Hawaiian Islands EEZ conducted in 2010 (Bradford et al., 2013), the best available abundance estimate for the Hawaii stock of rough-toothed dolphins is 6,288 individuals (CV = 0.39). Although island-specific stocks are not currently recognized by NMFS for management purposes, abundance estimates are provided in the most recent stock assessment report (Carretta et al., 2015) for Kauai/Niihau (1,665 individuals; CV = 0.33) and Hawaii Island (198 individuals; CV = 0.12). The island-specific estimates are based on photographic identification surveys conducted primarily within 40 km of shore and are not considered representative of abundance within the Hawaiian Islands EEZ.

Predator/Prey Interactions

Prey of rough-toothed dolphins includes fish and cephalopods. They are known to feed on large fish species, such as mahi mahi (Miyazaki and Perrin, 1994; Pitman and Stinchcomb, 2002). They also prey on reef fish, as Perkins and Miller (1983) noted that parts of reef fish had been found in the stomachs of stranded rough-toothed dolphins in Hawaii. Gannier and West (2005) observed rough-toothed dolphins feeding during the day on near-surface fishes, including flying fishes.

Although this species has not been documented as prey by other species, it may be subject to predation from killer whales.

Species-Specific Threats

Rough-toothed dolphins are particularly susceptible to commercial and recreational fishery interactions.

4.20 Fraser's Dolphin (*Lagenodelphis hosei*)

Although information on Fraser's dolphin has increased in recent years, the species is still one of the least-known cetaceans. Fraser's dolphin was discovered in 1956, and after that time was known only from skeletal remains until it was once again identified in the early 1970s (Perrin et al., 1973).

Status and Management

Fraser's dolphin is protected under the MMPA and is not listed under the ESA. For the MMPA stock assessment reports, there is a single Pacific management stock that includes only animals found within the Hawaiian Islands EEZ.

Geographic Range and Distribution

General. Fraser's dolphin is a tropical oceanic species, except where deep water approaches the coast (Dolar, 2008).

Insular Pacific-Hawaiian Large Marine Ecosystem. Fraser's dolphins have only recently been documented within the Insular Pacific-Hawaiian Large Marine Ecosystem. The first published sightings were during a 2002 cetacean survey (Barlow, 2006; Carretta et al., 2010), at which time the mean group size recorded was 286 (Barlow, 2006). An additional sighting was recorded off the Island of Hawaii in 2008. There are no records of strandings of this species in the Hawaiian Islands (Maldini et al., 2005). Fraser's dolphin vocalizations have been documented in the Hawaiian Islands (Barlow et al., 2008; Barlow et al., 2004). It is not known whether Fraser's dolphins found in Hawaiian waters are part of the same population that occurs in the eastern tropical Pacific (Carretta et al., 2010).

Open Ocean. In the offshore eastern tropical Pacific, this species is distributed mainly in upwelling-modified waters (Au and Perryman, 1985; Reilly, 1990). The range of this species includes deep open ocean waters of the North Pacific Gyre and the Insular Pacific-Hawaiian Large Marine Ecosystem and other locations in the Pacific (Aguayo and Sanchez, 1987; Ferguson, 2005; Miyazaki and Wada, 1978).

This does not appear to be a migratory species, and little is known about its potential migrations. No specific information regarding routes, seasons, or resighting rates in specific areas is available.

Population and Abundance

The current best available abundance estimate for the Hawaii stock of Fraser's dolphin derives from a 2002 shipboard survey of the entire Hawaiian Islands EEZ, resulting in an estimate of 16,992 (CV = 0.66) (Bradford et al., 2013).

Predator/Prey Interactions

Fraser's dolphin feeds on mid-water fishes, squids, and shrimps and has not been documented to be prey to any other species (Jefferson and Leatherwood, 1994; Perrin et al., 1994b). It may, however, be subject to predation by killer whales.

Species-Specific Threats

There are no significant species-specific threats to Fraser's dolphins in the Study Area.

4.21 Risso's Dolphin (*Grampus griseus*)

Status and Management

Risso's dolphin is protected under the MMPA and is not listed under the ESA. For the MMPA stock assessment reports, Risso's dolphins within the Pacific U.S. EEZ are divided into two separate areas: waters off California, Oregon, and Washington and Hawaiian waters (Carretta et al., 2010).

Geographic Range and Distribution

General. In the Pacific, the range of this species is known to include the North Pacific Gyre and the California Current and Insular Pacific-Hawaiian Large Marine Ecosystems. Occurrence of this species is well known in deep open ocean waters off Hawaii and in other locations in the Pacific (Au and Perryman, 1985; Carretta et al., 2010; Leatherwood et al., 1980; Miyashita, 1993; Miyashita et al., 1996; Wang et al., 2001).

Insular Pacific-Hawaiian Large Marine Ecosystem. Risso's dolphins have been considered rare in Hawaiian waters (Shallenberger, 1981). However, during a 2002 survey of the Hawaiian Islands EEZ, seven sightings were reported; in addition, two sightings were reported from recent aerial surveys in the Hawaiian Islands (Barlow, 2006; Mobley et al., 2000). During a more recent 2010 systematic survey of the Hawaiian Islands EEZ, there were 12 sightings of Risso's dolphins. In 2009, Risso's dolphins were acoustically detected near Hawaii using boat-based hydrophones (U.S. Department of the Navy, 2009). In addition, Risso's dolphins were sighted eight times during Navy monitoring activities within HRC between 2005 and 2012 (HDR, 2012). Five stranding records exist from the Main Hawaiian Islands (Maldini et al., 2005).

Open Ocean. Several studies have documented that Risso's dolphins are found offshore, along the continental slope, and over the outer continental shelf (Baumgartner, 1997; Canadas et al., 2002; Cetacean and Turtle Assessment Program, 1982; Davis et al., 1998; Green et al., 1992; Kruse et al., 1999; Mignucci-Giannoni, 1998). Risso's dolphins are also found over submarine canyons (Mussi et al., 2004).

Risso's dolphin does not migrate, although schools may range over very large distances. Seasonal shifts in centers of abundance are known for some regions.

Population and Abundance

This is a widely distributed species that occurs in all major oceans, and although no global population estimates exist, it is generally considered to be one of the most abundant of the large dolphins. The current best available abundance estimate for the Hawaiian stock of Risso's dolphin derives from a 2010 shipboard survey of the entire Hawaiian Islands EEZ (Bradford et al., 2013). The resulting abundance estimate is 7,526 individuals (CV = 0.41).

Predator/Prey Interactions

Cephalopods and crustaceans are the primary prey for Risso's dolphins (Clarke, 1996), which feed mainly at night (Baird et al., 2008; Jefferson et al., 2015). This dolphin may be preyed on by both killer whales and sharks, although there are no documented reports of predation by either species (Weller, 2008).

Species-Specific Threats

Risso's dolphins are particularly susceptible to entanglement and fisheries interactions.

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

Status and Management

Cuvier's beaked whale is protected under the MMPA and is not listed under the ESA. Cuvier's beaked whale stocks are defined for three separate areas within Pacific U.S. waters: (1) Alaska; (2) California, Oregon, and Washington; and (3) Hawaii.

Geographic Range and Distribution

General. Cuvier's beaked whales have an extensive range that includes all oceans, from the tropics to the polar waters of both hemispheres. Worldwide, beaked whales normally inhabit continental slope and deep oceanic waters. Cuvier's beaked whales are generally sighted in waters with a bottom depth greater than 655 feet (199.6 m) and are frequently recorded in waters with bottom depths greater than 3,280 feet (999.7 m) (Falcone et al., 2009; Jefferson et al., 2015). Cuvier's beaked whale range is known to include all waters of the Insular Pacific-Hawaiian Large Marine Ecosystems, the North Pacific Gyre, and the North Pacific Transition Zone (Jefferson et al., 2015; MacLeod and D'Amico, 2006).

Insular Pacific-Hawaiian Large Marine Ecosystem. Cuvier's beaked whales are regularly found in waters surrounding the Hawaiian Islands, having been sighted from vessels and aerial surveys. A line-transect survey conducted in February 2009 by the Cetacean Research Program surrounding the Hawaiian

Islands (Oleson and Hill, 2009) resulted in the sighting of 2 Cuvier's beaked whales, while shipboard surveys of the Hawaiian Islands EEZ in 2020 (Bradford et al., 2013) resulted in 22 sightings. They typically are found at depths exceeding 6,560 feet (2,000 m) (Baird et al., 2009b; Baird et al., 2006b; Barlow et al., 2004). In the Hawaiian Islands, five strandings have been reported from Midway Island, Pearl and Hermes Reef, Oahu, and the Island of Hawaii (Maldini et al., 2005; Shallenberger, 1981). Sightings have been reported off the Hawaiian Islands of Lanai, Maui, Hawaii, Niihau, and Kauai, supporting the hypothesis that there is a resident population found in the Hawaiian Islands (Baird et al., 2010b; Carretta et al., 2010; Mobley et al., 2000; Shallenberger, 1981).

Open Ocean. Cuvier's beaked whales are widely distributed in offshore waters of all oceans and thus occur in temperate and tropical waters of the Pacific, including waters of the eastern tropical Pacific (Barlow et al., 2006; Ferguson, 2005; Jefferson et al., 2015; Pitman et al., 1988). In the Study Area, they are found mostly offshore in deeper waters off Hawaii (MacLeod and Mitchell, 2006; Mead, 1989; Ohizumi and Kishiro, 2003; Wang et al., 2001). A single population likely exists in offshore waters of the eastern north Pacific, ranging from Alaska south to Mexico (Carretta et al., 2010). Little is known about potential migration.

Population and Abundance

The current best available abundance estimate for the Hawaii stock is 1,941 individuals (CV = 0.70), based on a 2010 shipboard line-transect survey of the Hawaiian Islands EEZ (Bradford et al., 2013).

Predator/Prey Interactions

Cuvier's beaked whales, similar to other beaked whale species, are apparently deepwater feeders. Stomach content analyses show that they feed mostly on deep-sea squid, fish, and crustaceans (Hickmott, 2005; Santos et al., 2007). They apparently use suction to swallow prey (Jefferson et al., 2015; Werth, 2006a; Werth, 2006b). Cuvier's beaked whales may be preyed upon by killer whales (Heyning and Mead, 2008; Jefferson et al., 2015).

Species-Specific Threats

Cuvier's beaked whales commonly strand, and they are considered vulnerable to acoustic impacts (Frantzis et al., 2002; Cox et al., 2006; Southall et al., 2012). Additionally, Cuvier's beaked whales have been documented being entangled in fishing gear.

4.23 Blainville's Beaked Whale (*Mesoplodon densirostris*)

Status and Management

Due to difficulty in distinguishing the different *Mesoplodon* species from one another, the U.S. management unit is usually defined to include all *Mesoplodon* species that occur in an area. Blainville's beaked whale is protected under the MMPA and is not listed under the ESA. Although little is known of stock structure for this species, based on resightings and genetic analysis of individuals around the Hawaiian Islands, NMFS recognizes a Hawaii stock of Blainville's beaked whale.

Geographic Range and Distribution

General. Blainville's beaked whales are one of the most widely distributed of the distinctive toothed whales within the *Mesoplodon* genus (Jefferson et al., 2015; MacLeod and Mitchell, 2006). Blainville's beaked whale range is known to include the Insular Pacific-Hawaiian Large Marine Ecosystems, North Pacific Gyre, and the North Pacific Transition Zone (Jefferson et al., 2015; Pitman, 2008).

Insular Pacific-Hawaiian Large Marine Ecosystem. Blainville's beaked whales are regularly found in Hawaiian waters (Baird, Hanson, et al., 2003; Baird et al., 2006b; Barlow et al., 2004). In Hawaiian waters, this species is typically found in areas where water depths exceed 3,280 feet (1,000 m) along the continental slope (Barlow et al., 2006; Baird et al., 2010b). Blainville's beaked whale has been detected off the coast of Oahu, Hawaii, for prolonged periods annually, and this species is consistently observed in the same site off the west coast of the island of Hawaii (McSweeney et al., 2007). Blainville's beaked whales' vocalizations have been detected on acoustic surveys in the Hawaiian Islands, and stranding records are available for the region (Maldini et al., 2005; Rankin and Barlow, 2007). A recent tagging study off the island of Hawaii found the movements of a Blainville's beaked whale to be restricted to the waters of the west and north side of the island (Baird et al., 2010b). Blainville's beaked whales were detected in nearshore waters off the western shore of Kauai during passive acoustic and visual surveys in 2014.

Open Ocean. Blainville's beaked whales are found mostly offshore in deeper waters along the California coast, Hawaii, Fiji, Japan, and Taiwan, as well as throughout the eastern tropical Pacific (Leslie et al., 2005; MacLeod and Mitchell, 2006; Mead, 1989). It is unknown whether this species makes specific migrations, and none have so far been documented. Populations studied in Hawaii have evidenced some level of residency (McSweeney et al., 2007).

Population and Abundance

The best available abundance estimate for Blainville's beaked whale Hawaii stock is based on a 2010 shipboard line-transect survey of the entire Hawaiian Islands EEZ (Bradford et al., 2013). The resulting estimate is 2,338 individuals (CV = 1.13).

Predator/Prey Interactions

This species preys on squid and possibly deepwater fish. Like other *Mesoplodon* species, Blainville's beaked whales apparently use suction for feeding (Jefferson et al., 2015; Werth, 2006a; Werth, 2006b). This species has not been documented to be prey to any other species although, like other cetaceans, it is likely subject to occasional killer whale predation.

Species-Specific Threats

Blainville's beaked whales have been shown to react to anthropogenic noise by avoidance (Tyack et al., 2011). In response to a simulated sonar signal and pseudorandom noise (a signal of pulsed sounds that are generated in a random pattern), a tagged whale ceased foraging at depth and slowly moved away from the source while gradually ascending toward the surface (Tyack et al., 2011).

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

Status and Management

Longman's beaked whale is protected under the MMPA and is not listed under the ESA. Longman's beaked whale is a rare beaked whale species and is considered one of the world's least-known cetaceans (Dalebout et al., 2003; Pitman, 2008). Only one Pacific stock, the Hawaii stock, is identified (Carretta et al., 2010).

Geographic Range and Distribution

General. Longman's beaked whales generally are found in warm tropical waters, with most sightings occurring in waters with sea surface temperatures warmer than 78° Fahrenheit (26° Celsius) (Anderson et al., 2006; MacLeod and D'Amico, 2006; MacLeod, Hauser, et al., 2006). Sighting records of this species in the Indian Ocean showed Longman's beaked whale typically found over deep slopes 655 to 6,560 (or more) feet (200 to 2,000 [or more] m) (Anderson et al., 2006).

Although the full extent of this species distribution is not fully understood, there have been many recorded sightings at various locations in tropical waters of the Pacific and Indian Oceans (Afsal et al., 2009; Dalebout et al., 2002; Dalebout et al., 2003; Moore, 1972). Ferguson et al. (2001) reported that all Longman's beaked whale sightings were south of 25° N.

Records of this species indicate presence in the eastern, central, and western Pacific. The range of Longman's beaked whale generally includes the Insular Pacific-Hawaiian Large Marine Ecosystems and the North Pacific Gyre (Gallo-Reynoso and Figueroa-Carranza, 1995; Jefferson et al., 2015; MacLeod and D'Amico, 2006).

Insular Pacific-Hawaiian Large Marine Ecosystem. Sighting records for this species indicate presence in waters to the west of the Hawaiian Islands (four Longman's beaked whales were observed during the 2002 Hawaiian Islands Cetacean and Ecosystem Assessment, also known as the HICEAS survey [Barlow et al., 2004]) and to the northwest of the Hawaiian archipelago (23°42'38" N and 176°33'78" W). During a more recent 2010 HICEAS survey, there were multiple sightings of Longman's beaked whale. Longman's beaked whales have also been sighted off Kona (Cascadia Research, 2012b). Shipboard surveys of the Hawaiian Islands EEZ in 2010 resulted in three sightings (Bradford et al., 2013). Two known records exist of this species stranding in the Hawaiian Islands (Maldini et al., 2005; West et al., 2012).

Open Ocean. Worldwide, Longman's beaked whales normally inhabit continental slope and deep oceanic waters (greater than 655 feet [200 m]) and are only occasionally reported in waters over the continental shelf (Canadas et al., 2002; Ferguson et al., 2006; MacLeod, Hauser, et al., 2006; Pitman, 2008; Waring et al., 2001).

Little information regarding the migration of this species is available, but it is considered to be widely distributed across the tropical Pacific and Indian Oceans (Jefferson et al., 2015). It is unknown whether the Longman's beaked whale participates in a seasonal migration (Jefferson et al., 2015; Pitman, 2008).

Population and Abundance

Based on 2010 surveys of the Hawaiian Islands EEZ (Bradford et al., 2013), the best available abundance estimate of the Hawaii stock is 4,571 individuals (CV = 0.65).

Predator/Prey Interactions

Based on recent tagging data from Cuvier's and Blainville's beaked whales, Baird et al. (2005b) suggested that feeding for Longman's beaked whale might occur at mid-water rather than only at or near the bottom (Heyning, 1989; MacLeod et al., 2003). This species has not been documented to be prey to any other species, though it is likely subject to occasional killer whale predation.

Species-Specific Threats

Little information exists regarding species-specific threats to Longman's beaked whales in the Study Area. However, recently the first case of morbillivirus in the central Pacific was documented for a stranded juvenile male Longman's beaked whale at Hamoa Beach, Hana, Maui (West et al., 2012).

4.25 Hawaiian Monk Seal (*Neomonachus schauinslandi*)

Status and Management

The Hawaiian monk seal was listed as endangered under the ESA in 1976 and is listed as depleted under the MMPA. The species is considered a high priority for recovery, based on the high magnitude of threats, the high recovery potential, and the potential for economic conflicts while implementing recovery actions (NMFS, 2007b). Hawaiian monk seals are managed as a single stock. NMFS has identified reproductive subpopulations at French Frigate Shoals, Laysan Island, Lisianski Island, Pearl and Hermes Reef, Midway Atoll, Kure Atoll, and Necker and Nihoa Islands in the Northwestern Hawaiian Islands (NMFS, 2014). The species also occurs throughout the Main Hawaiian Islands (e.g., there is a population of approximately 200 individuals in the Main Hawaiian Islands [NMFS, 2016] and the total population is estimated to be fewer than 1,200 individuals). The approximate area encompassed by the Northwestern Hawaiian Islands was designated as the Papahānaumokuākea Marine National Monument in 2006.

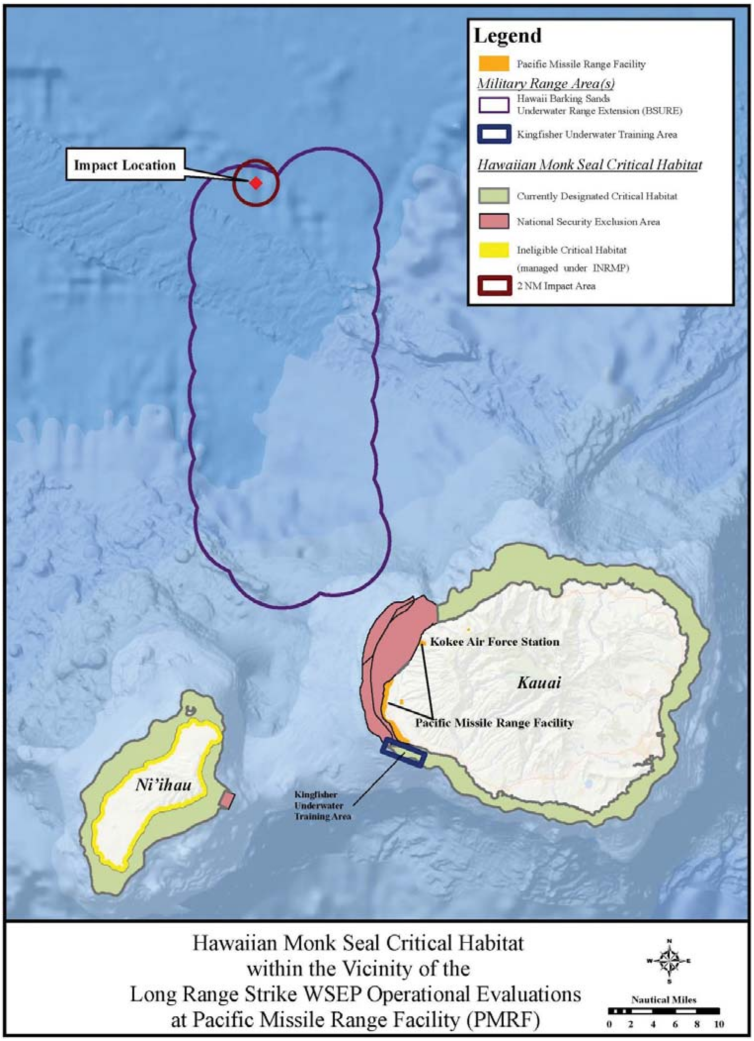
A recovery plan for the Hawaiian monk seal was completed in 1983 and was revised in 2007 (NMFS, 2007b). In 1986, critical habitat was designated for all beach areas, sand spits and islets, lagoon waters, inner reef waters, and ocean waters to a depth of 10 fathoms (18.3 m) around Kure Atoll, Midway Islands (except Sand Island), Pearl and Hermes Reef, Lisianski Island, Laysan Island, Gardner Pinnacles, French Frigate Shoals, Necker Island, and Nihoa Island in the Northwestern Hawaiian Islands (NMFS, 1986). In 1988, the critical habitat was extended to include Maro Reef and waters around previously recommended areas out to the 20 fathom (36.6 m) isobath (NMFS, 1988). In order to reduce the probability of direct interaction between Hawaiian-based long-line fisheries and monk seals, a Protected Species Zone was established in the Northwestern Hawaiian Islands, prohibiting long-line fishing in this zone. In 2000, the waters from 3 to 50 NM around the Northwestern Hawaiian Islands were designated as the Northwestern Hawaiian Islands Coral Reef Ecosystem Reserve, and specific restrictions were placed on human activities there (Antonelis et al., 2006).

In 2008, NMFS received a petition requesting that the critical habitat in the Northwestern Hawaiian Islands be expanded to include Sand Island at Midway and ocean waters out to a depth of 500 m and that the following critical habitat be added in the Main Hawaiian Islands: key beach areas, sand spits and islets, lagoon waters, inner reef waters, and ocean waters to a depth of 200 m. In 2009, NMFS announced a 12-month finding indicating the intention to revise critical habitat, and in 2011 NMFS proposed that critical habitat in the Northwestern Hawaiian Islands be expanded to include Sand Island at Midway and ocean waters out to a depth of 500 m and that six new extensive areas in the Main Hawaiian Islands be added. In August 2015, NMFS published a final rule revising critical habitat designation to include 10 areas in the Northwestern Hawaiian Islands and 6 areas in the Main Hawaiian Islands (50 CFR Part 226, 21 August 2015). NMFS excluded several areas from designation because either (1) the national security benefits of exclusion outweigh the benefits of inclusion (and exclusion will not result in extinction of the species), or (2) they are managed under Integrated Natural Resource Management Plans that provide a benefit to the species (these areas are termed “ineligible” for critical habitat designation). Critical Habitat Specific Area 13 includes portions of the Kauai coastline and associated marine waters. However, portions of the PMRF were excluded, including the PMRF Main Base at Barking Sands and the PMRF Offshore Areas in marine areas off the western coast of Kauai. Hawaiian monk seal critical habitat is shown in Figure 4-1.

The Pacific Island Regional Office of NMFS has the lead responsibility for the recovery of Hawaiian monk seals under the ESA and the MMPA. Since the early 1980s, NMFS has routinely applied flipper tags to weaned pups in the Northwestern Hawaiian Islands (Antonelis et al., 2006). NMFS performed capture and release programs through the Head Start Program between 1981 and 1991, “to enhance the survival of young females and thereby increase their subsequent recruitment into the adult female population.” From 1984 to 1995, under NMFS’s Rehabilitation Project, undersized, weaned female pups from French Frigate Shoals and, in some cases, undersized juvenile females, were brought into captivity for 8 to 10 months on Oahu to increase their weight. They were then released into the wild at either Kure Atoll or Midway Islands, where they had a higher probability of survival (Antonelis et al., 2006). Because some males were injuring female seals, in July and August of 1994, 21 adult male Hawaiian monk seals were relocated from Laysan Island to the Main Hawaiian Islands (NMFS, 2009). NMFS has relocated three female monk seals (a juvenile in 1981, a pup in 1991, and an adult in 2009) from the Main Hawaiian Islands to the Northwestern Hawaiian Islands (NMFS, 2009).

Other agencies that also play an important role in the Northwestern Hawaiian Islands are the Marine Mammal Commission; the USFWS, which manages wildlife habitat and human activities within the lands and waters of the Hawaiian Islands National Wildlife Refuge and the Midway Atoll National Wildlife Refuge; the U.S. Coast Guard, which assists with enforcement and efforts to clean up marine pollution; the National Ocean Service, which conserves natural resources in the Northwestern Hawaiian Islands Coral Reef Ecosystem Reserve; and the Western Pacific Regional Fishery Management Council, which develops fishery management plans and proposes regulations to NMFS for commercial fisheries around the Northwestern Hawaiian Islands (Marine Mammal Commission, 2002).

Figure 4-1. Critical Habitat of the Hawaiian Monk Seal near the Study Area



The State of Hawaii also has important responsibilities for monk seal conservation and recovery. It owns Kure Atoll and has jurisdiction over waters between the reserve boundary and 3 NM around all emergent lands in the Northwestern Hawaiian Islands (except Midway) (Marine Mammal Commission, 2002). In March 2007, the State of Hawaii put new regulations into place to restrict the use of lay nets on Oahu, Molokai, Lanai, Kauai, and Niihau and prohibited lay net use in state waters around the entire island of Maui and certain areas on Oahu (NMFS, 2010b). In 2008, in hopes of raising awareness of the species, Hawaii's Lieutenant Governor signed into law legislation that established the Hawaiian monk seal as the official state mammal.

When seals are reported on beaches in the main islands, NMFS works with state and local agencies to cordon off sections of beach around the seals. NMFS also relies on volunteer groups to observe seals and educate the public about their endangered status and protection measures. On Oahu, the Hawaiian Monk Seal Response Team Oahu is a team of over 50 volunteers who routinely assist NOAA Fisheries Pacific Island Regional Office and the Pacific Island Fisheries Science Center in monk seal response issues. Monk seal response programs also exist on Kauai, Maui, and the Island of Hawaii, with some reporting from Molokai and Lanai (NMFS, 2010b).

There is also a multiagency marine debris working group that was established in 1998 to remove derelict fishing gear, which has been identified as a top threat to this species, from the Northwestern Hawaiian Islands (Donohue and Foley, 2007). Agencies involved in these efforts include The Ocean Conservancy, the City and County of Honolulu, the Coast Guard, the USFWS, the Hawaii Wildlife Fund, the Hawaii Sea Grant Program, the National Fish and Wildlife Foundation, the Navy, the University of Alaska Marine Advisory Program, and numerous other state and private agencies and groups (Marine Mammal Commission, 2002).

The Navy has previously funded some monk seal tagging projects conducted by Pacific Islands Fisheries Science Center personnel. In addition, since 2013, some collaborative projects have been undertaken under the PMRF Integrated Natural Resources Management Plan.

Geographic Range and Distribution

General. Monk seals can rapidly cover large areas in search of food and may travel hundreds of miles in a few days (Littnan et al., 2007).

Insular Pacific-Hawaiian Large Marine Ecosystem. The Hawaiian monk seal is the only endangered marine mammal whose range is entirely within the United States (NMFS, 2007b). Hawaiian monk seals can be found throughout the Hawaiian Island chain in the Insular Pacific-Hawaiian Large Marine Ecosystem. Sightings have also occasionally been reported on nearby island groups south of the Hawaiian Island chain, such as Johnston Atoll, Wake Island, and Palmyra Atoll (Carretta et al., 2010; Gilmartin and Forcada, 2009; Jefferson et al., 2015; NMFS, 2009). The main breeding sites are in the Northwestern Hawaiian Islands: French Frigate Shoals, Laysan Island, Lisianski Island, Pearl and Hermes Reef, Midway Atoll, Kure Atoll, and Necker and Nihoa Islands. Monk seals have also been observed at Gardner Pinnacles and Maro Reef. A small breeding population of monk seals is found throughout the Main Hawaiian Islands, where births have been documented on most of the major islands, especially Kauai (Gilmartin and Forcada, 2009; NMFS, 2007b; NMFS, 2010c). It is possible that, before Western contact, Polynesians drove many Hawaiian monk seals from the Main Hawaiian Islands to less desirable habitat in the Northwestern Hawaiian Islands (Baker and Johanos, 2004).

Although the Hawaiian monk seal is found primarily on the Northwestern Hawaiian Islands (NMFS, 2014), sightings on the Main Hawaiian Islands have become more common (Johanos et al., 2015). During Navy-funded marine mammal surveys from 2007 to 2012, there were 41 sightings of Hawaiian monk seals, with a total of 58 individuals on or near Kauai, Kaula, Niihau, Oahu, and Molokai (HDR, 2012). Forty-seven (81 percent) individuals were seen during aerial surveys, and 11 (19 percent) during vessel surveys. Monk seals were most frequently observed at Niihau.

Monk seals are generally thought to spend most of their time at sea in nearshore, shallow marine habitats (Littnan et al., 2007). However, recent research suggests that the seals may use the open ocean more extensively than previously thought (see the *Predator/Prey Interactions* subsection below). When hauled out, Hawaiian monk seals seem to prefer beaches of sand, coral rubble, and rocky terraces (Baker et al., 2006; Jefferson et al., 2015).

Climate models predict that global average sea levels may rise this century, potentially affecting species that rely on the coastal habitat. Topographic models of the low-lying Northwestern Hawaiian Islands were created to evaluate potential effects of sea level rise by 2100. Monk seals, which require the islands for resting, molting, and nursing, may experience more crowding and competition if islands shrink (Baker et al., 2006).

Based on one study, on average, 10 to 15 percent of the monk seals migrate among the Northwestern Hawaiian Islands and the Main Hawaiian Islands (Carretta et al., 2010). Another source suggests that about 36 percent of the main Hawaiian Island seals travel between islands throughout the year (Littnan, 2011).

Population and Abundance

Currently, the best estimate for the total population of monk seals is 1,153 (Carretta et al., 2015). Population dynamics at the different locations in the Northwestern Hawaiian Islands and the Main Hawaiian Islands has varied considerably (Antonelis et al., 2006). A population model for 2003 through 2012 suggests a decline in overall population of about 3.3 percent. However, the Main Hawaiian Islands population appears to be increasing, possibly at a rate of about 7 percent per year (NMFS, 2014). In the Main Hawaiian Islands, a minimum abundance of 45 seals was found in 2000, and this increased to 52 in 2001 (Baker, 2004). In 2009, 113 individual seals were identified in the Main Hawaiian Islands based on flipper tag ID numbers or unique natural markings. The total number in the Main Hawaiian Islands is currently estimated to be about 200 animals (NMFS, 2016). Beach counts in the Northwestern Hawaiian Islands since the late 1950s have shown varied population trends at specific times, but in general, abundance is low at most islands (NMFS, 2014).

Possible links between the spatial distribution of primary productivity in the Northwestern Hawaiian Islands and trends of Hawaiian monk seal abundance have been assessed for the past 40 years. Results demonstrate that monk seal abundance trends appear to be affected by the quality of local environmental conditions (including sea surface temperature, vertical water column structure, and integrated chlorophyll) (Schmelzer, 2000). Limited prey availability may be restricting the recovery of the Northwestern Hawaiian Islands monk seals (Baker, 2008; Brillinger et al., 2006; Carretta et al., 2010). Studies performed on pup survival rate in the Northwestern Hawaiian Islands between 1995 and 2004 showed severe fluctuations between 40 percent and 80 percent survival in the first year of life. Survival rates between 2004 and 2008 showed an increase at Lisianski Island and Pearl, Hermes, Midway, and Kure Atoll and a decrease at French Frigate Shoals and Laysan Island. Larger females have a higher survival rate than males and smaller females (Baker, 2008).

Estimated chances of survival from weaning to age one are higher in the Main Hawaiian Islands (77 percent) than in the Northwestern Hawaiian Islands (42 to 57 percent) (Littnan, 2011). The estimated Main Hawaiian Islands intrinsic rate of population growth is greater as well. If current trends continue, abundances in the Main Hawaiian Islands could eventually exceed that of the Northwestern Hawaiian Islands (NMFS, 2014). There are a number of possible reasons why pups in the Main Hawaiian Islands are faring better. One is that the per capita availability of prey may be higher in the Main Hawaiian Islands, due to the low monk seal population (Baker and Johanos, 2004). Another may have to do with the structure of the marine communities. In the Main Hawaiian Islands, the seals have less competition with other top predators, like large sharks, jacks, and other fish, which may enhance their foraging success (Baker and Johanos, 2004; Parrish et al., 2008).

A third factor may be the limited amount of suitable foraging habitat in the Northwestern Hawaiian Islands (Stewart et al., 2006). While foraging conditions are better in the Main Hawaiian Islands than in the Northwestern Hawaiian Islands, health hazards from exposure to pollutants and infectious disease agents associated with terrestrial animals pose risks not found in the Northwestern Hawaiian Islands (Littnan et al., 2007). Despite these risks, a self-sustaining subpopulation in the Main Hawaiian Islands could improve the monk seal's long-term prospects for recovery (Baker and Johanos, 2004; Carretta et al., 2005; Marine Mammal Commission, 2003).

Predator/Prey Interactions

The Hawaiian monk seal is a foraging generalist, often moving rocks to capture prey underneath (NMFS, 2014). Monk seals feed on many species of fish, cephalopods, and crustaceans. Prey species include representatives of at least 31 bony fish families, 13 cephalopod (octopus, squid, and related species) families, and numerous crustaceans (e.g., crab and lobster). Foraging typically occurs on the seafloor from the shallows to water depths of over 500 m. Data from tagged individuals indicate foraging occurs primarily in areas of high bathymetric relief within 40 km (25 miles) of atolls or islands, although submerged banks and reefs located over 300 km from breeding sites may also be used (NMFS, 2014). In general, seals associated with the Main Hawaiian Islands appear to have smaller home ranges, travel shorter distances to feed, and spend less time foraging than seals associated with the Northwestern Hawaiian Islands. The inner reef waters next to the islands are critical to weaned pups learning to feed; pups move laterally along the shoreline, but do not appear to travel far from shore during the first few months after weaning (Gilmartin and Forcada, 2009). Feeding has been observed in reef caves, as well as on fish hiding among coral formations (Parrish et al., 2000). A recent study showed that this species is often accompanied by large predatory fish, such as jacks, sharks, and snappers, which possibly steal or compete for prey that the monk seals flush with their probing, digging and rock-flipping behavior. The juvenile monk seals may not be of sufficient size or weight to get prey back once it has been stolen. This was noted only in the French Frigate Shoals (Parrish et al., 2008).

Monk seals and are known to be preyed on by both killer whales and sharks. Shark predation is one of the major sources of mortality for this species especially in the Northwestern Hawaiian Islands. Galapagos sharks are a large source of juvenile mortality in the Northwestern Hawaiian Islands, with most predation occurring in the French Frigate Shoals (Antonelis et al., 2006; Gilmartin and Forcada, 2009; Jefferson et al., 2015).

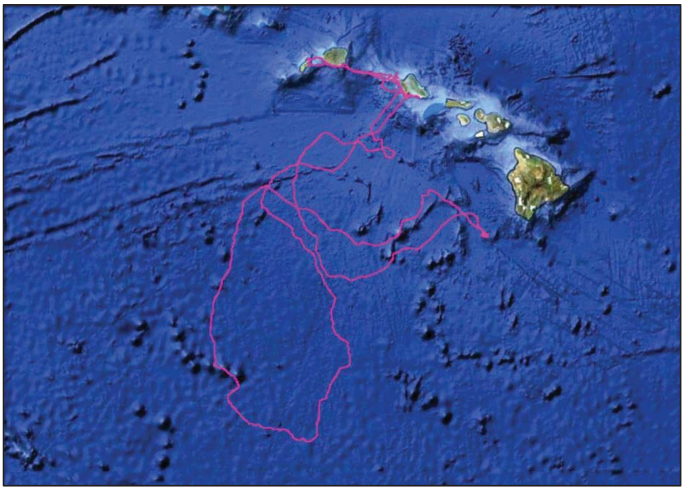
In an effort to better understand the habitat needs of foraging monk seals, Stewart et al. (2006) used satellite-linked radio transmitters to document the geographic and vertical foraging patterns of 147 Hawaiian monk seals from all six Northwestern Hawaiian Islands breeding colonies, from 1996 through 2002. Geographic patterns of foraging were complex and varied among colonies by season, age, and sex, but some general patterns were evident. Seals were found to forage extensively within barrier reefs of the atolls and on the leeward slopes of reefs and islands at all colony sites. They also ranged away from these sites along the Hawaiian Islands submarine ridge to most nearby seamounts and submerged reefs and banks (Stewart et al., 2006).

In 2005, 11 juvenile and adult monk seals were tracked in the Main Hawaiian Islands using satellite-linked radio transmitters showing location, but not depth (Littnan et al., 2007). Similar to the Northwestern Hawaiian Islands, monk seals showed a high degree of individual variability. Overall results showed most foraging trips to last from a few days to two weeks, with seals remaining within the 200 m isobaths surrounding the Main Hawaiian Islands and nearby banks (Littnan et al., 2007).

NMFS and the Navy have also monitored monk seals with cell phone tags (Littnan, 2011; Reuland, 2010). Results from one individual monk seal (R012) indicated travel of much greater distances and water depths than previously documented (Littnan, 2011). The track of this monk seal extended as much as 470 miles (756.4 km) from shore and a total distance of approximately 2,000 miles (3,218.7 km) where the ocean depth is over 5,000 m (Figure 4-2). However, the distance traveled by this individual was substantially greater than that of foraging trips undertaken by other seals in the study and may not represent typical behavior (Littnan, 2012).

Figure 4-2. Track of Hawaiian Monk Seal R012 in June 2010

Source: NOAA Fisheries, 2015



Species-Specific Threats

Monk seals are particularly susceptible to fishery interactions and entanglements. In the Northwestern Hawaiian Islands, derelict fishing gear has been identified as a top threat to the monk seal (Donohue and Foley, 2007), while in the Main Hawaiian Islands, high risks are associated with health hazards from exposure to pollutants and infectious disease agents associated with terrestrial animals. Limited prey availability may be restricting the recovery of the Northwestern Hawaiian Islands monk seals (Baker, 2008; Brillinger et al., 2006; Carretta et al., 2010). Since they rely on coastal habitats for survival, monk seals may be affected by future sea level rise and loss of habitat as predicted by global climate models. Another species-specific threat includes aggressive male monk seals that have been documented to injure and sometimes kill females and pups (NMFS, 2010b). Other threats include reduced prey availability, shark predation, disease and parasites, and contaminants (NMFS, 2014).

This page is intentionally blank.

5.0 TAKE AUTHORIZATION REQUESTED

The MMPA established, with limited exceptions, a moratorium on the "taking" of marine mammals in waters under U.S. jurisdiction. The act further regulates "takes" of marine mammals in the high seas by vessels or persons under U.S. jurisdiction. The term *take*, as defined in Section 3 (16 United States Code [USC] 1362) of the MMPA, means "to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal." *Harassment* was further defined in the 1994 amendments to the MMPA, which provided for two levels: Level A (potential injury) and Level B (potential disturbance).

The National Defense Authorization Act of fiscal year 2004 (Public Law 108-136) amended the definition of harassment for military readiness activities. Military readiness activities, as defined in Public Law 107-314, Section 315(f), includes all training and operations related to combat and the adequate and realistic testing of military equipment, vehicles, weapons, and sensors for proper operation and suitability for combat. This definition, therefore, includes air-to-surface test activities occurring in the BSURE. The amended definition of harassment for military readiness activities is any act that:

- Injures or has the significant potential to injure a marine mammal or marine mammal stock in the wild ("Level A harassment") or
- Disturbs or is likely to disturb a marine mammal or marine mammal stock in the wild by causing disruption of natural behavioral patterns including but not limited to migration, surfacing, nursing, breeding, feeding, or sheltering to a point where such behavioral patterns are abandoned or significantly altered ("Level B harassment") (16 USC 1362 [18][B][i],[ii]).

Section 101(a)(5) of 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 (exclusive of commercial fishing) within a specified geographic region. These incidental takes may be allowed if NMFS determines the taking will have a negligible impact on the species or stock and the taking will not have an unmitigable adverse impact on the availability of such species or stock for taking for subsistence uses.

Pursuant to Section 101(a)(5), a LOA for the incidental taking (but not intentional taking) of marine mammals is requested for air-to-surface evaluation activities within the BSURE area, as described in Section 1, *Description of Activities*. The results of acoustic modeling for surface detonations associated with the evaluation missions indicate the potential for Level A and Level B (physiological and behavioral) harassment, and take is requested for these levels of impact. It is expected that the mitigation measures identified in Section 11 will decrease the potential for impacts. The subsequent analyses in this request will identify the applicable types of take.

In addition to protections provided to all marine mammals by the MMPA, some species are also listed under the ESA (see Table 4-2). Potential impacts to species listed under the ESA are further analyzed in a separate Biological Assessment, prepared by the Air Force pursuant to Section 7 of the ESA.

This page is intentionally blank.

6.0 NUMBERS AND SPECIES TAKEN

Potential impacts to marine mammals resulting from Long Range Strike WSEP mission activities, including munition strikes, ingestion of military expended materials, and detonation effects (overpressure and acoustic components), are discussed in the following subsections.

6.1 Physical Strike

Marine mammals could be physically struck by weapons during Long Range Strike WSEP missions. During the five-year period of 2017 to 2021, a total of 550 bombs and missiles will be deployed, for an average of 110 per year. All weapons will be deployed in summer. The velocity of bombs, missiles, and other munitions decreases quickly after striking the water and, therefore, injury and mortality are considered unlikely for animals swimming in the water column at a depth of more than a few meters. Strike potential would generally be limited to animals located at the water surface or in the water column near the surface and would be affected by factors such as size and relative speed of the munition. Strike potential would be reduced by pre-mission surveys, avoidance of observed marine mammals in the mission area, and the generally dispersed distribution of marine mammals. Although the probability of a direct strike by test weapons is not quantified, the Air Force considers it to be low.

6.2 Ingestion Stressors

Military expended materials that would be produced during Long Range Strike WSEP missions include inert munitions and fragments of exploded bombs and missiles. Intact, inert munitions would be too large to ingest. However, some munition fragments could be ingested by some species, possibly resulting in injury or death.

A small quantity of exploded weapons components, such as small plastic pieces, could float on the surface. Species feeding at the surface could incidentally ingest these floating items. Sei whales are known to skim feed, and there is potential for other species to feed at the surface. Laist (1997) provides a review of numerous marine mammal species that have been documented to ingest debris, including 21 odontocetes. Most of these species had apparently ingested debris floating at the surface. A marine mammal would suffer a negative impact from military expended materials if the item becomes imbedded in tissue or is too large to pass through the digestive system. Some of the items would be small enough to pass through an animal's digestive system without harm. In addition, an animal would not likely ingest every expended item it encountered. The number of items at the surface encountered by a given animal would be decreased by the low initial density of items and dispersal by currents and wind. Due to the small amount of floating military expended materials produced and the dispersed nature of marine mammals and marine mammal groups potentially encountering an item at the surface, floating military expended materials are unlikely to negatively affect marine mammals.

Most military expended materials would not remain on the water surface but would sink at various rates of speed, depending on the density and shape of the item. Individual marine mammals feeding in the water column (for example, dolphins preying on fish or squid at middle depths) could potentially ingest a sinking item. Most items would sink relatively quickly and would not remain suspended in the water column indefinitely. In addition, not all items encountered would be ingested, as a marine mammal would probably be able to distinguish military expended materials from prey in many instances. Overall, sinking items are not expected to present a substantial ingestion threat to marine mammals.

Most of the military expended materials resulting from Long Range Strike WSEP missions would sink to the bottom and would probably eventually become encrusted and/or covered by sediments, although cycles of covering/exposure could occur due to water currents. Several marine mammal species feed at or near the seafloor. For example, although sperm whales feed primarily on squid (presumably deep in the water column), demersal fish species are also sometimes consumed. Humpback whales may also feed near the bottom, and beaked whales use suction feeding to ingest benthic prey. Hawaiian monk seals feed on numerous species that may occur on or near the seafloor, including fish, cephalopods, and lobsters. Therefore, there is some potential for such species to incidentally ingest military expended materials while feeding. However, the potential for such encounters is low based on the relatively low number and patchy distribution of the items produced, the patchy distribution of marine mammal feeding habitat, and water depth at the impact location (over 4,000 meters). Further, an animal would not likely ingest every military expended material it encounters. Animals may attempt to ingest an item and then reject it after realizing it is not a food item. Additionally, ingestion of an item would not necessarily result in injury or mortality to the individual if the item does not become embedded in tissue (Wells et al., 2008). Therefore, impacts resulting from ingestion of military expended materials would be limited to the unlikely event that a marine mammal suffers a negative response from ingesting an item that becomes embedded in tissue or is too large to pass through the digestive system. Military expended materials that become encrusted or covered by sediments would have a lower potential for ingestion. In general, it is not expected that large numbers of items on the seafloor would be consumed and result in harm to marine mammals, particularly given the water depth at the impact location. Based on the discussion above, the Air Force considers potential impacts unlikely and population-level effects on any species are considered remote.

6.3 Detonation Effects

Cetaceans spend their entire lives in the water and are submerged below the surface much of the time. When at the surface, unless engaging in behaviors such as jumping, spyhopping, etc., the body is almost entirely below the water's surface, with only the blowhole exposed to allow breathing. This can make cetaceans difficult to locate visually and also exposes them to underwater noise, both natural and anthropogenic, most of the time because their ears are nearly always below the water's surface. Hawaiian monk seals spend some portion of their time out of the water. However, when swimming under the surface (e.g., during foraging dives), seals are also exposed to natural and anthropogenic noise. As a result, marine mammals located near a surface detonation could be exposed to the resulting shock wave and acoustic energy. Potential effects include mortality, injury, impacts to hearing, and behavioral disturbance.

The potential numbers and species of marine mammal exposures are assessed in this section. Appendix A provides a description of the acoustic modeling methodology used to estimate exposures, as well as the model outputs. Three sources of information are necessary for estimating potential acoustic effects on marine mammals: (1) the zone of influence, which is the distance from an explosion to which particular levels of impact would extend; (2) the density of animals within the zone of influence; and (3) the number of detonations (events). Each of these components is described in the following subsections.

Zone of Influence

The zone of influence is defined as the area or volume of ocean in which marine mammals could be exposed to various pressure or acoustic energy levels caused by exploding ordnance. Refer to Appendix A for a description of the method used to calculate impact volumes for explosives. The pressure and energy levels considered to be of concern are defined in terms of metrics, criteria, and thresholds. A *metric* is a technical standard of measurement that describes the acoustic environment (e.g., frequency duration, temporal pattern, and amplitude) and pressure at a given location. *Criteria* are the resulting types of possible impact and include mortality, injury, and harassment. A *threshold* is the level of pressure or noise above which the impact criteria are reached. The analysis of potential impacts to marine mammals incorporates criteria and thresholds presented in Finneran and Jenkins (2012). The paragraphs below provide a general discussion of the various metrics, criteria, and thresholds used for impulsive noise impact assessment. More detailed information is provided in Appendix A.

Metrics

Standard impulsive and acoustic metrics were used for the analysis of underwater energy and pressure waves in this document. Several different metrics are important for understanding risk assessment analysis of impacts to marine mammals.

SPL (sound pressure level): A ratio of the absolute sound pressure to a reference level. Units are in decibels referenced to 1 micropascal (dB re 1 μPa).

SEL (sound exposure level): SEL is a measure of sound intensity and duration. When analyzing effects on marine animals from multiple moderate-level sounds, it is necessary to have a metric that quantifies cumulative exposures. SEL can be thought of as a composite metric that represents both the intensity of a sound and its duration. SEL is determined by calculating the decibel level of the cumulative sum-of-squared pressures over the duration of a sound, with units of decibels referenced to 1 micropascal-squared seconds (dB re 1 $\mu Pa^2 \cdot s$) for sounds in water.

Positive impulse: This is the time integral of the pressure over the initial positive phase of an arrival. This metric represents a time-averaged pressure disturbance from an explosive source. Units are typically pascal-seconds (Pa·s) or pounds per square inch per millisecond (psi·msec). There is no decibel analog for impulse.

Criteria and Thresholds

The criteria and thresholds used to estimate potential pressure and acoustic impacts to marine mammals resulting from detonations were obtained from Finneran and Jenkins (2012) and include mortality, injurious harassment (Level A), and non-injurious harassment (Level B). In some cases, separate thresholds have been developed for different species groups or functional hearing groups. Functional hearing groups included in the analysis are low-frequency cetaceans, mid-frequency cetaceans, high-frequency cetaceans, and phocids. A more detailed description of each of the criteria and thresholds is provided in Appendix A.

Mortality

Mortality risk assessment may be considered in terms of direct injury, which includes primary blast injury and barotrauma. The potential for direct injury of marine mammals has been inferred from terrestrial mammal experiments and from post-mortem examination of marine mammals believed to have been exposed to underwater explosions (Finneran and Jenkins, 2012; Ketten et al., 1993; Richmond et al., 1973). Actual effects on marine mammals may differ from terrestrial animals due to anatomical and physiological differences, such as a reinforced trachea and flexible thoracic cavity, which may decrease the risk of injury (Ridgway and Dailey, 1972).

Primary blast injuries result from the initial compression of a body exposed to a blast wave and is usually limited to gas-containing structures (e.g., lung and gut) and the auditory system (U.S. Department of the Navy, 2001). Barotrauma refers to injuries caused when large pressure changes occur across tissue interfaces, normally at the boundaries of air-filled tissues such as the lungs. Primary blast injury to the respiratory system may be fatal depending upon the severity of the trauma. Rupture of the lung may introduce air into the vascular system, producing air emboli that can restrict oxygen delivery to the brain or heart.

Whereas a single mortality threshold was previously used in acoustic impacts analysis, species-specific thresholds are currently required. Thresholds are based on the level of impact that would cause extensive lung injury resulting in mortality to 1 percent of exposed animals (that is, an impact level from which 1 percent of exposed animals would not recover) (Finneran and Jenkins, 2012). The threshold represents the expected onset of mortality, where 99 percent of exposed animals would be expected to survive. Most survivors would have moderate blast injuries. The lethal acoustic exposure level of a blast, associated with the positive impulse pressure of the blast, is expressed as Pa·s and is determined using the Goertner

(1982) modified positive impulse equation. This equation incorporates source/animal depths and the mass of a newborn calf for the affected species. The threshold is conservative because animals of greater mass can withstand greater pressure waves, and newborn calves typically make up a very small percentage of any marine mammal group. While the mass of newborn calves for some species are provided in literature, in many cases this information is unknown and a surrogate species (considered to be generally comparable in mass) is used instead. Finneran and Jenkins (2012) provide known or surrogate masses for newborn calves of several cetacean species. The Goertner equation, as presented in Finneran and Jenkins (2012), is used in the acoustic model to develop impacts analysis in this LOA request. The equation is provided in Appendix A.

Injury (Level A Harassment)

Three categories of blast-related injury (Level A harassment) are currently recognized by NMFS: gastrointestinal (GI) tract injury, slight lung injury, and irrecoverable auditory damage (permanent threshold shift).

Gastrointestinal Tract Injuries. Though often secondary in life-threatening severity to pulmonary blast trauma, the GI tract can also suffer contusions and lacerations from blast exposure, particularly in air-containing regions of the tract. Although hemorrhage of solid organs (e.g., liver, spleen, and kidney) from blast exposure is possible, rupture of these organs is rarely encountered. GI tract injuries are correlated with the peak pressure of an underwater detonation. GI tract injury thresholds are based on the results of experiments in the 1970s in which terrestrial mammals were exposed to small charges. The peak pressure of the shock wave was found to cause recoverable contusions (bruises) in the GI tract (Richmond et al., 1973; Finneran and Jenkins, 2012). The experiments found that a peak SPL of 237 dB re 1 μPa predicts the onset of GI tract injuries, regardless of an animal's mass or size. Therefore, the unweighted peak SPL of 237 dB re 1 μPa is used in explosive impacts assessments as the threshold for slight GI tract injury for all marine mammals.

Slight Lung Injury. This threshold is based on a level of exposure where most animals may experience slight blast injury to the lungs, but all would survive (0 percent mortality) (Finneran and Jenkins, 2012). Similar to the mortality determination, the metric is positive impulse and the equation for determination is that of the Goertner injury model (1982), corrected for atmospheric and hydrostatic pressures and based on the cube root scaling of body mass (Richmond et al., 1973; U.S. Department of the Navy, 2001). The equation is provided in Appendix A.

Auditory Damage (Permanent Threshold Shift). Another type of injury correlated to Level A harassment is permanent threshold shift (PTS), which is auditory damage that does not recover and results in a permanent decrease in hearing sensitivity. There have been no studies to determine the onset of PTS in marine mammals and, therefore, this threshold must be estimated from other available information. Finneran and Jenkins (2012) define separate PTS thresholds for three groups of cetaceans based on hearing sensitivity (low-frequency, mid-frequency, and high-frequency), and for phocids. Dual criteria are provided for PTS thresholds, one based on the SEL and one based on the SPL of an underwater blast. For a given analysis, the more conservative of the two is typically applied. The PTS thresholds are provided in Appendix A.

Non-Injurious Impacts (Level B Harassment)

Two categories of non-injurious Level B harassment are currently recognized: temporary threshold shift (TTS) and behavioral impacts. Although TTS is a physiological impact, it is not considered injury because auditory structures are temporarily fatigued instead of being permanently damaged.

Temporary Threshold Shift. Non-injurious effects on marine mammals, such as TTS, are generally extrapolated from data on terrestrial mammals (Southall et al., 2007). Similar to PTS, dual criteria are provided for TTS thresholds, and the more conservative is typically applied in impacts analysis. TTS criteria are based on data from impulse sound exposures when available. If impulse TTS data are not available, data from non-impulse exposures may be used (adjusted for the relationship between impulse and non-impulse TTS observed in dolphins and belugas). For species where no data exist, TTS thresholds are based on the most closely related species for which data are available. The TTS thresholds are provided in Appendix A.

Behavioral Impacts. Behavioral impacts refer to disturbances that may occur at acoustic levels below those considered to cause TTS in marine mammals, particularly in cases of multiple detonations. During an activity with a series of explosions (not concurrent multiple explosions), an animal is expected to exhibit a startle reaction to the first detonation followed by a behavioral response after multiple detonations. At close ranges and high sound levels, avoidance of the area around the explosions is the assumed behavioral response in most cases. Behavioral impacts may include decreased ability to feed, communicate, migrate, or reproduce, among others. Such effects, known as sub-TTS Level B harassment, are based on observations of behavioral reactions in captive dolphins and beluga whales exposed to pure tones, a different type of sound than that produced from a detonation (Finneran and Schlundt, 2004; Schlundt et al., 2000). Behavioral effects are generally considered to occur when animals are exposed to multiple, successive detonations at the same location within a 24-hour period. For single detonations, behavioral disturbance is likely limited to short-term startle reactions. The behavioral impact thresholds for marine mammals exposed to multiple, successive detonations are provided in Appendix A.

Marine Mammal Density

Density estimates for marine mammals occurring in the Study Area are provided in Table 3-4. As discussed in Section 3, marine mammal density estimates were obtained from the U.S. Navy's Marine Species Density Database (U.S. Department of the Navy, 2014), which provides the most relevant and comprehensive density information for waters associated with the HRC. Density is typically reported for an area (e.g., animals per square kilometer). Density estimates usually assume that animals are uniformly distributed within the affected area, even though this is rarely true. Marine mammals may be clumped in areas of greater importance; for example, animals may be more concentrated in areas offering high productivity, lower predation, safe calving, etc. However, because there are usually insufficient data to calculate density for small areas, an even distribution is typically assumed for impact analyses.

Although the Study Area is depicted as only the surface of the water, in reality, density implicitly includes animals anywhere within the water column under that surface area. Assuming that marine mammals are distributed evenly within the water column does not accurately reflect animal behaviors. Databases of behavioral and physiological parameters obtained through tagging and other technologies have demonstrated that marine animals use the water column in various ways. Some species conduct regular deep dives while others engage in much shallower dives, regardless of bottom depth. The depth distribution for each species included in the Study Area is provided in Appendix B. Combining marine mammal density with depth information would allow impact estimates to be based on three-dimensional density distributions, likely resulting in more accurate modeling of potential exposures. However, based on current regulatory guidance, density is assumed to be two-dimensional, and exposure estimates are therefore simply calculated as the product of affected area, animal density, and number of events. The resulting exposure estimates are considered conservative because all animals are presumed to be located at the same depth, where the maximum sound and pressure ranges would extend from detonations, and would therefore be exposed to the maximum amount of energy or pressure. In reality, it is highly likely that some portion of marine mammals present near the impact area at the time of detonation would be at various depths in the water column and not necessarily occur at the same depth corresponding to the maximum sound and pressure ranges.

Number of Events

An "event" refers to a single, unique action that has the potential to expose marine mammals to pressure and/or noise levels associated with take under the MMPA. For Long Range Strike WSEP activities, the number of events generally corresponds to the number of live ordnance items released within a 24-hour period. With the exception of SDB-I/II bombs, each live munition would detonate separately in time. Up to four SDBs may be released simultaneously and would detonate within a few seconds of each other in the same vicinity and is referred to as a "burst." The exact number and type of munitions that would be released each day is not known and would vary. To account for total annual impacts, the total number of each munition proposed to be released per year was divided by five (annual number of mission days) and treated as a representative mission day. The total energy for all weapon releases as part of a representative mission day is summed for impact calculations. There will be a total of five mission days per year during the time frame of 2017–2021. Refer to Appendix A for a detailed explanation of modeling methods.

Exposure Estimates

The maximum estimated range, or radius, from the detonation point to which the various thresholds extend for all munitions proposed to be released in a 24-hour time period was calculated based on explosive acoustic characteristics, sound propagation, and sound transmission loss in the Study Area, which incorporates water depth, sediment type, wind speed, bathymetry, and temperature/salinity profiles (Table 6-1). The ranges were used to calculate the total area (circle) of the zones of influence for each criterion/threshold. To eliminate "double-counting" of animals, impact areas from higher impact categories (e.g., mortality) were subtracted from areas associated with lower impact categories (e.g., Level A harassment). The estimated number of marine mammals potentially exposed to the various impact thresholds was then calculated as the product of the adjusted impact area, animal density, and number of events per year. Since the acoustic model accumulates the energy from all detonations within a 24-hour time frame, it is assumed that the same population of animals is being impacted within that time period. The population would refresh after 24 hours. Since five mission days are planned annually for 2017 to 2021, take estimates from the representative mission day were multiplied by five to determine the total annual numbers of take. Details of the acoustic modeling method are provided in Appendix A. For metrics with multiple criteria (e.g., slight lung injury, GI tract injury, and PTS for Level A harassment) and criteria with two thresholds (e.g., 187 dB SEL and 230 peak SPL for PTS), the criterion and/or threshold that results in the higher exposure estimate is presented in the table and used for impact calculations.

The resulting total number of marine mammals potentially exposed to the various levels of thresholds is listed in Table 6-2. An animal is considered "exposed" to a sound if the received sound level at the animal's location is above the background ambient acoustic level within a similar frequency band. The exposure calculations from the model output resulted in decimal values, suggesting in most cases that a fraction of an animal was exposed. To eliminate this, the acoustic model results were rounded to the nearest whole animal to obtain the exposure estimates. For impact categories with multiple criteria and/or thresholds (e.g., three criteria and four thresholds associated with Level A harassment), numbers in the table are based on the criterion and threshold resulting in the greatest number of exposures. Exposure levels include the possibility of injury and non-injurious harassment (including behavioral harassment) to marine mammals in the absence of mitigation measures. The numbers represent total impacts for all detonations combined and do not take into account the required mitigation and monitoring measures (Section 11), which are expected to decrease the number of exposures shown in the table.

Table 6-1. Threshold Radii (in meters) for a Long Range Strike WSEP Typical Mission Day

Species	Mortality	Level A Harassment				Level B Harassment		
		Slight Lung Injury	GI Tract Injury	PTS		TTS		Behavioral
	Based on Goertner (1982)	Based on Richmond et al. (1973)	237 dB SPL	Applicable SEL*	Applicable SPL*	Applicable SEL*	Applicable SPL*	Applicable SEL*
Humpback whale	99	200	204	3,744	413	13,836	763	56,233
Blue whale	74	149	204	3,744	413	13,836	763	56,233
Fin whale	76	157	204	3,744	413	13,836	763	56,233
Sei whale	101	204	204	3,744	413	13,836	763	56,233
Bryde's whale	99	200	204	3,744	413	13,836	763	56,233
Minke whale	138	268	204	3,744	413	13,836	763	56,233
Sperm whale	91	177	204	1,290	413	7,016	763	10,648
Pygmy sperm whale	248	457	204	13,797	5,024	57,933	8,176	70,921
Dwarf sperm whale	273	509	204	13,797	5,024	57,933	8,176	70,921
Killer whale	149	287	204	1,290	413	7,016	763	10,648
False killer whale (MHI Insular stock)	177	340	204	1,290	413	7,016	763	10,648
False killer whale (all other stocks)	177	340	204	1,290	413	7,016	763	10,648
Pygmy killer whale	324	604	204	1,290	413	7,016	763	10,648
Short-finned pilot whale	217	413	204	1,290	413	7,016	763	10,648
Melon-headed whale	273	502	204	1,290	413	7,016	763	10,648
Bottlenose dolphin	273	509	204	1,290	413	7,016	763	10,648
Pantropical spotted dolphin	324	604	204	1,290	413	7,016	763	10,648
Striped dolphin	324	604	204	1,290	413	7,016	763	10,648
Spinner dolphin	324	604	204	1,290	413	7,016	763	10,648
Rough-toothed dolphin	273	509	204	1,290	413	7,016	763	10,648
Fraser's dolphin	257	480	204	1,290	413	7,016	763	10,648
Risso's dolphin	207	384	204	1,290	413	7,016	763	10,648
Cuvier's beaked whale	131	257	204	1,290	413	7,016	763	10,648
Blainville's beaked whale	195	368	204	1,290	413	7,016	763	10,648
Longman's beaked whale	133	261	204	1,290	413	7,016	763	10,648
Hawaiian monk seal	306	564	204	3,267	1,394	10,539	2,549	51,690

GI = gastrointestinal; MHI = Main Hawaiian Islands; PTS = permanent threshold shift; SEL = sound exposure level; SPL = sound pressure level; TTS = temporary threshold shift
*Based on the applicable Functional Hearing Group

Table 6-2. Number of Marine Mammals Potentially Affected by Long Range Strike WSEP Missions

Species	Mortality	Level A Harassment (PTS)	Level B Harassment (TTS)	Level B Harassment (Behavioral)
Mysticetes (baleen whales)				
Humpback whale	0	0	0	0
Blue whale	0	0	0	0
Fin whale	0	0	0	0
Sei whale	0	0	0	0
Bryde's whale	0	0	0	0
Minke whale	0	0	0	0
Odontocetes (toothed whales and dolphins)				
Sperm whale	0	0	1	2
Pygmy sperm whale	0	9	145	76
Dwarf sperm whale	0	21	355	188
Killer whale	0	0	0	0
False killer whale (MHI Insular stock)	0	0	0	1
False killer whale (all other stocks)	0	0	1	1
Pygmy killer whale	0	0	3	4
Short-finned pilot whale	0	0	7	9
Melon-headed whale	0	0	1	2
Bottlenose dolphin	0	0	2	3
Pantropical spotted dolphin	0	0	5	6
Striped dolphin	0	0	3	3
Spinner dolphin	0	0	2	2
Rough-toothed dolphin	0	0	4	5
Fraser's dolphin	0	0	3	5
Risso's dolphin	0	0	4	5
Cuvier's beaked whale	0	0	0	0
Blainville's beaked whale	0	0	1	1
Longman's beaked whale	0	0	2	3
Pinnipeds				
Hawaiian monk seal	0	0	0	1
Total	**0**	**30**	**539**	**317**

PTS = permanent threshold shift; TTS = temporary threshold shift; WSEP = Weapon Systems Evaluation Program

7.0 IMPACTS TO MARINE MAMMAL SPECIES OR STOCKS

A variety of effects may result from exposure to sound-producing activities. The severity of the effects can range from minor effects with no real cost to the animal to more severe effects that may have lasting consequences. The types of effects potentially experienced by marine mammals, as well as the estimated number of animals potentially affected, is provided in the following paragraphs. None of the estimates take into account the mitigation measures outlined in Section 11, which are expected to reduce the number and severity of effects. Impacts are expected to be recoverable; therefore, no adverse population level effects are anticipated.

Marine mammals potentially affected by Long Range Strike WSEP activities conducted in the BSURE area include cetaceans (mysticetes and odontocetes). One pinniped, the Hawaiian monk seal (listed as endangered under the ESA and considered depleted under the MMPA), occurs in the Study Area. Humpback and blue whales potentially affected are part of the Central North Pacific stocks, which are both listed as endangered under the ESA and considered depleted under the MMPA. Fin, sei, Bryde's, and minke whales are associated with the Hawaii stocks. Fin and sei whales are listed as endangered under the ESA and considered depleted under the MMPA. The Bryde's and minke whale stocks are not listed under the ESA or considered strategic under the MMPA.

The sperm whale (Hawaii stock) and Main Hawaiian Island Insular stock of false killer whale are listed as endangered under the ESA and are considered depleted under the MMPA. No other potentially affected odontocete stocks are listed under the ESA or considered depleted under the MMPA. Most of the other odontocetes are associated with Hawaii stocks (pygmy sperm whale, dwarf sperm whale, killer whale, pygmy killer whale, short-finned pilot whale, striped dolphin, Fraser's dolphin, Risso's dolphin, rough-toothed dolphin, Cuvier's beaked whale, Blainville's beaked whale, and Longman's beaked whale). The remaining odontocetes (false killer whale, melon-headed whale, bottlenose dolphin, pantropical spotted dolphin, and spinner dolphin) are part of stock complexes, which generally consist of stocks associated with particular islands, multi-island regions, or pelagic waters around Hawaii.

The numbers of marine mammals potentially experiencing overpressure or acoustic exposure due to surface detonations are provided in Section 6, *Numbers and Species Taken*. A variety of effects may result from exposure to sound-producing activities. The severity of the effects can range from minor effects with no real cost to the animal to more severe effects that may have lasting consequences. The types of effects potentially experienced by marine mammals, as well as the estimated number of animals potentially affected, is provided in the following paragraphs. None of the estimates take into account the mitigation measures outlined in Section 11, which are expected to reduce the number and severity of effects.

Based on acoustic modeling described in Section 6 and Appendix A, no marine mammals would be affected by impulse pressure levels associated with mortality, slight lung injury, or GI tract injury. A total of 30 marine mammals (9 pygmy sperm whales and 21 dwarf sperm whales) could potentially be exposed to injurious Level A harassment resulting from PTS auditory injury. Auditory injury is a reduction in hearing ability resulting from overstimulation to sounds. The mechanisms differ from those of auditory trauma and include damage or distortion of the tympanic membrane and hair cells, hair cell death, changes in cochlear blood flow, and cochlear nerve swelling. Auditory injury is manifested as hearing loss, also called noise-induced threshold shift. Level A harassment is associated with permanent effects (PTS), where some portion of the threshold shift remains indefinitely. Animals are most susceptible to auditory injury within their most sensitive hearing range. The greater the degree of threshold shift, the smaller the ocean space within which an animal can detect biologically relevant sounds. For example, deafness would affect social communications, navigation, foraging, and predator detection. The threshold resulting in the highest exposure estimates was used to determine takes, which in this document is the applicable SEL threshold. If an animal suffers trauma or auditory injury, a physiological stress response will typically occur. A stress response generally involves the release of hormones and other biochemicals into the bloodstream to help the animal in responding to the stressor.

A total of approximately 539 marine mammals could potentially be exposed to sound corresponding to non-injurious (TTS) Level B harassment. Most odontocete species have some calculated level of estimated TTS exposure, including one exposure of the ESA-listed sperm whale. However, most exposures are associated with pygmy and dwarf sperm whale (combined total of 500 exposures). TTS impacts are not expected for any mysticete species. Similar to the preceding discussion of auditory injury, auditory fatigue is a reduction in hearing ability resulting from overstimulation to sounds that may result from damage or distortion of the tympanic membrane and hair cells, hair cell death, changes in cochlear blood flow, and cochlear nerve swelling. The distinction between PTS and TTS is based on whether there is complete recovery of hearing sensitivity following a sound exposure. If the animal's hearing ability eventually returns to pre-exposure levels, the threshold shift is considered temporary. Studies of terrestrial mammals show that large amounts of TTS (approximately 40 dB measured 24 hours after exposure) can result in permanent neural degeneration, despite the hearing thresholds returning to normal. As with PTS, animals are most susceptible to auditory fatigue within their most sensitive hearing range. The greater the degree of threshold shift, the smaller the ocean space within which an animal can detect biologically relevant sounds. In this document, the threshold resulting in the highest exposure estimates was used to determine takes. Similar to the discussion of PTS, the SEL metrics resulted in higher exposure estimates compared with peak SPL metrics and were conservatively used for impacts analysis.

Approximately 317 additional marine mammals could potentially be exposed to acoustic levels corresponding to applicable behavioral thresholds during Long Range Strike WSEP missions. Most odontocete species have some calculated level of estimated behavioral impact, including the ESA-listed sperm whale (two estimated exposures) and false killer whale (Main Hawaiian Insular stock) (one estimated exposure). However, similar to the results for TTS, most exposures are associated with the pygmy and dwarf sperm whale. One behavioral exposure is also estimated for the Hawaiian monk seal. Behavioral impacts are not expected for any mysticete species. Behavioral harassment occurs at distances beyond the range of structural damage and hearing threshold shift. Numerous behavioral responses can result from physiological responses. An animal may react to a stimulus based on a number of factors in addition to the severity of the physiological response. An animal's previous experience with the same or a similar sound, the context of the exposure, and the presence of other stimuli contribute to determining its reaction. Behavioral responses fall into two major categories: alterations in natural behavior patterns and avoidance. These types of reactions are not mutually exclusive, and overall reactions may be combinations of behaviors or a sequence of behaviors. Severity of behavioral reactions can vary substantially, from minor and brief reorientations of the animal to investigate the sound to severe reactions such as aggression or prolonged flight. The type and severity of the behavioral response will determine the energetic cost to the animal. Possible behavioral responses to a detonation include panic, startle, departure from an area, and disruption of activities such as feeding or breeding, among others.

The magnitude and type of effect, as well as the speed and completeness of recovery, affect the long-term consequences to individual animals and populations. Animals that recover quickly and completely from explosive effects will not likely suffer reductions in their health or reproductive success or experience changes in their habitat utilization. In such cases, no population-level effects would be expected. Animals that do not recover quickly and fully could suffer reductions in their health and reproductive success, they could be permanently displaced or change how they utilize the environment, or they could die. Frequent disruptions to natural behavior patterns may not allow an animal to fully recover between exposures, which increases the probability of causing long-term consequences to individuals. Long-term consequences to individuals can lead to population-level consequences.

Consideration of "negligible impact" is required by NMFS to authorize incidental take of marine mammals. An activity has a negligible impact on a species or stock when it is determined that the total taking is not likely to reduce annual rates of adult survival or recruitment (offspring survival, birth rates). Potential impacts associated with the proposed actions consist of Level A harassment (PTS) and Level B harassment (TTS and behavioral effects). Behavioral reactions of marine mammals to sound are known to occur but are difficult to predict. Behavioral studies indicate that reactions to sounds, if any, are highly contextual and vary between species and individuals within a species (Moretti et al., 2010; Southall et al., 2011; Thompson et al, 2010; Tyack, 2009b; Tyack et al., 2011). Depending on the context, marine mammals often change their activity when exposed to disruptive levels of sound. For example, when sound becomes potentially disruptive, cetaceans at rest become active and feeding or socializing cetaceans or pinnipeds often interrupt these events by diving or swimming away. Recent studies on the effects of active sonar (a non-impulsive sound) on marine mammals have been undertaken within the PMRF. Martin et al. (2015) found that the number of minke whale calls detected on the range's hydrophones decreased with the use of active sonar (during the time frame of 2011 to 2013). Blainville's beaked whales underwent fewer dives during sonar use compared with periods without sonar use, and there is some indication that individuals moved toward the edges of the range (Martin et al., 2016). Conversely, Baird et al. (2014) investigated movements of satellite-tagged bottlenose dolphins, short-finned pilot whales, and rough-toothed dolphins exposed to active sonar and found no indication of large-scale movement away from the sound, although the authors note some limitations in the study. If sound disturbance occurs around a haulout site, pinnipeds may move back and forth between water and land or eventually abandon the site. When attempting to understand behavioral disruption by anthropogenic sound, a key consideration is whether the exposures have biologically significant consequences for the individual or population (National Research Council, 2005).

If a marine mammal does react to an underwater sound by changing its behavior or moving a small distance, the impacts of the change may not be important to the individual. For example, researchers have found during a study of dolphins' response to whale watching vessels in New Zealand that when animals can cope with constraint and easily feed or move elsewhere, there is little effect on survival (Lusseau and Bejder, 2007). On the other hand, if a sound source displaces marine mammals from an important feeding or breeding area for a prolonged period and they do not have an alternate equally desirable area, impacts on the marine mammal could be negative because the disruption has biological consequences. Biological parameters or key elements having greatest importance to a marine mammal relate to its ability to mature, reproduce, and survive.

The importance of the disruption and degree of consequence for individual marine mammals is often dependent on the frequency, intensity, and duration of the disturbance. Isolated acoustic disturbances such as underwater detonations are expected to have minimal consequences and no lasting consequences on marine mammal populations. Marine mammals regularly cope with occasional disruption of their activities by predators, adverse weather, and other natural phenomena. It is reasonable to assume that they can tolerate occasional or brief disturbances by anthropogenic sound without significant consequences. A prolonged disturbance, as might occur if a stationary and noisy activity were established near a concentrated area, is a more important concern.

The following points provide a context for evaluating the potential to impact individual marine mammals or marine mammal populations:

- Estimated mortality impacts are zero.
- Most acoustic harassment effects are within the non-injurious TTS or behavioral effects zones (Level B harassment); the estimated number of animals potentially affected by Level A harassment (injury) is relatively small (30 exposures).
- The take numbers presented in Section 6 and summarized in the preceding paragraphs are likely conservative (overestimates) because they do not take into account the mitigation measures

described in Section 11. These measures are expected to substantially decrease the potential for explosive and acoustic impacts, especially within the injury zone. In addition, exposure calculations are based on the assumption that all animals would occupy the same depth within the water column and do not take into account diving behavior, which could decrease exposure levels.

8.0 IMPACT ON SUBSISTENCE USE

Potential marine mammal impacts resulting from the proposed activities will be limited to individuals located in the Study Area and that have no subsistence requirements. Therefore, no impacts on the availability of species or stocks for subsistence use are considered.

This page is intentionally blank.

9.0 IMPACTS TO MARINE MAMMAL HABITAT AND THE LIKELIHOOD OF RESTORATION

The primary sources of marine mammal habitat impact are acoustic and pressure waves resulting from live weapon detonations. However, neither the sound nor overpressure constitutes a long-term physical alteration of the water column or ocean floor. Further, these effects are not expected to substantially affect prey availability, are of limited duration, and are intermittent in time. Therefore, it is not anticipated that marine mammals will stop utilizing the waters of the Study Area, either temporarily or permanently, as a result of mission activities.

Other factors that could potentially affect marine mammal habitat include the introduction of metals, explosives and explosion by-products, other chemical materials, and debris into the water column and substrate due to the use of munitions and effect to prey distribution. The effects of metals, explosives and explosion by-products, other chemical materials, and debris are analyzed in the associated Long Range Strike WSEP EA/OEA, prepared in accordance with the National Environmental Policy Act. Based on the review in the EA/OEA, there would be no significant effects to marine mammals resulting from loss or modification of marine mammal habitat including water and sediment quality. Refer to the EA/OEA for more detailed discussion of these components.

Marine mammals in the Study Area feed on various fish and invertebrates. Physical effects from pressure and acoustic waves generated by surface detonations could affect these prey species near the detonation point, potentially decreasing their availability to marine mammals. In particular, the rapid oscillation between high- and low-pressure peaks has the potential to burst the swim bladders and other gas-containing organs of fish (Keevin and Hemen, 1997). Sublethal effects, such as changes in behavior of fish, have been observed on several occasions as a result of noise produced by explosives (National Research Council, 2003; Wright, 1982). The abundances of various fish and invertebrates near the detonation point could be altered for a few hours before animals from surrounding areas repopulate the area; however, these populations would be replenished as waters near the detonation point are mixed with adjacent waters. Munition fragments resulting from testing activities could potentially result in minor long-term changes to benthic habitat. Similar to an artificial reef structure, such materials could be colonized over time by benthic organisms that prefer hard substrate and could provide structure that could attract some species of fish.

This page is intentionally blank.

10.0 IMPACTS TO MARINE MAMMALS FROM LOSS OR MODIFICATION OF HABITAT

Based on the discussions in Section 9, the proposed activities are not expected to have any habitat-related effects, such as from water quality, sediment quality, and prey availability, that could cause significant or long-term consequences for individual marine mammals or their populations. No permanent loss or modification of habitat would occur, and there would be no indirect impacts to marine mammals from temporarily altered habitat conditions. There will be no long-term impacts on marine mammals resulting from loss or modification of marine mammal habitat.

This page is intentionally blank.

11.0 MEANS OF AFFECTING THE LEAST PRACTICABLE ADVERSE IMPACTS

The potential takes discussed in Section 6 represent the maximum expected number of animals that could be exposed to particular acoustic and pressure thresholds. The impact estimates do not take into account measures that will be employed to minimize impacts to marine species. Unlike standard operating procedures, which are established for reasons other than environmental benefit, mitigation measures are modifications to the proposed activities that are implemented for the sole purpose of reducing a specific potential environmental impact on a particular resource. The procedures discussed in this section are, in general, routinely implemented for test events in the PMRF as a result of previous U.S. Navy environmental compliance documents, ESA biological opinions, MMPA incidental harassment authorizations or letters of authorization, or other formal or informal consultations with regulatory agencies. The Air Force has worked with PMRF personnel to ensure mitigation measures are adequate and meet NMFS' expectations based on requirements identified for past similar actions conducted in the PMRF and BSURE areas. The overall approach to assessing potential mitigation measures in the BSURE area is based on two principles: (1) mitigations will be effective at reducing potential impacts on the resource, and (2) mitigation is consistent with mission objectives, range procedures, and safety measures.

For missions involving air-to-surface weapon employment in the BSURE area, such as Long Range Strike WSEP activities, mitigation procedures consist of visual aerial surveys of the impact area for the presence of protected marine species (marine mammals and sea turtles). During aerial observation, Navy test range personnel may survey the area from an S-61N helicopter or C-62 aircraft that is based at the PMRF land facility (typically when missions are located relatively close to shore). Alternatively, when missions are located farther offshore, surveys may be conducted from mission aircraft (typically jet aircraft such as F-15E, F-16, or F-22) or a U.S. Coast Guard C-130 aircraft.

Protected species surveys typically begin within one hour of weapon release and as close to the impact time as feasible, given human safety requirements. Survey personnel must depart the human hazard zone before weapon release, in accordance with Navy safety standards. Personnel conduct aerial surveys within an area defined by an approximately 2-NM (3,704-m) radius around the impact point, with surveys typically flown in a star pattern. This survey distance is consistent with requirements already in place for similar actions at PMRF and encompasses the entire PTS threshold ranges (SEL) for all mid-frequency cetaceans and the Hawaiian monk seal, as well as nearly the entire PTS threshold ranges for low-frequency cetaceans (Table 6-1). The survey distance covers only about 27 percent of the PTS threshold range for high-frequency cetaceans (pygmy and dwarf sperm whales). The survey distance would not cover any of the energy-associated TTS or behavioral harassment ranges. Given operational constraints, surveying these larger areas would not be feasible.

Observers would consist of aircrew operating the C-26, S-61N, and C-130 aircraft from PMRF and the Coast Guard. These aircrew are trained and experienced at conducting aerial marine mammal surveys and have provided similar support for other missions at PMRF. Aerial surveys are typically conducted at an altitude of about 200 feet, but altitude may vary somewhat depending on sea state and atmospheric conditions. If adverse weather conditions preclude the ability for aircraft to safely operate, missions would either be delayed until the weather clears or cancelled for the day. The C-26 and other aircraft would generally be operated at a slightly higher altitude than the helicopter. The observers will be provided with the GPS location of the impact area. Once the aircraft reaches the impact area, pre-mission surveys typically last for 30 minutes, depending on the survey pattern. The fixed-wing aircraft are faster than the helicopter and, therefore, protected species may be more difficult to spot. However, to compensate for the difference in speed, the aircraft may fly the survey pattern multiple times.

If a protected species is observed in the impact area, weapon release would be delayed until one of the following conditions is met: (1) the animal is observed exiting the impact area, (2) the animal is thought to have exited the impact area based on its course and speed, or (3) the impact area has been clear of any additional sightings for a period of 30 minutes. All weapons will be tracked and their water entry points will be documented. Post-mission surveys would begin immediately after the mission is complete and the Range Safety Officer declares the human safety area is reopened. Approximate transit time from the perimeter of the human safety area to the weapon impact area would depend on the size of the human safety area and vary between aircraft but is expected to be less than 30 minutes. Post-mission surveys would be conducted by the same aircraft and aircrew that conducted the pre-mission surveys and would follow the same patterns as pre-mission surveys but would focus on the area down current of the weapon impact area to determine if protected species were affected by the mission (observation of dead or injured animals). Post-mission surveys are conducted by aircraft at the impact point and surrounding area to determine if protected species were affected by the mission (observation of dead or injured animals). If an injury or mortality occurs to a protected species due to Long Range Strike WSEP missions, NMFS would be notified immediately.

NMFS has specified the following reporting and activity requirements:

- In the unanticipated event that Long Range Strike WSEP activities clearly cause the take of a marine mammal in a manner not authorized by NMFS, the 86 FWS will immediately cease activities and report the incident to the NMFS Office of Protected Resources and the Regional Stranding Coordinator. Activities will not resume until NMFS reviews the circumstances of the take and determines what further measures are necessary to minimize the likelihood of further prohibited take.
- If an injured or dead marine mammal is discovered, and the cause of injury or death is unknown and the injury or death occurred relatively recently, the 86 FWS will immediately report the incident to the NMFS Office of Protected Resources and the Regional Stranding Coordinator. Activities may continue while NMFS reviews the incident.
- If an injured or dead marine mammal is discovered, and the observer determines that the injury or death is not related to Long Range Strike WSEP activities, the 86 FWS will report the incident to the NMFS Office of Protected Resources and the Regional Stranding Coordinator within 24 hours and may provide photographs, video footage, or other documentation of the affected animal.

12.0 MINIMIZATION OF ADVERSE EFFECTS ON SUBSISTENCE USE

Subsistence use is the traditional exploitation of marine mammals by native peoples (i.e., for their own consumption) inhabiting Arctic regions. In terms of the Long Range Strike WSEP LOA application, none of the proposed activities occur in or near the Arctic. Based on discussions in Section 7, there are no anticipated impacts on any species or stocks migrating through the Study Area that might be available for subsistence use.

This page is intentionally blank.

13.0 MONITORING AND REPORTING MEASURES

For Long Range Strike WSEP missions using live ordnance, the impact area will be visually surveyed for marine mammal presence prior to commencement of activities. Pre-mission surveys will be conducted from an S-61N helicopter, U.S. Coast Guard AC-130, jet aircraft, or C-62 aircraft. Post-mission surveys will also be carried out by the same aircraft. If any marine mammals are detected during pre-mission surveys, activities will be immediately halted until the area is clear of all marine mammals, as described in Section 11. During post-mission surveys, if an animal is found to have been injured or otherwise adversely impacted, NMFS will be notified.

This page is intentionally blank.

14.0 RESEARCH

Although the Air Force has conducted or supported marine species research in some areas of operation (for example, in the nearshore Gulf of Mexico where similar live air-to-surface testing and training occurs), the Air Force does not conduct research within the Navy's HRC.

This page is intentionally blank.

15.0 LIST OF PREPARERS

Amanda Robydek, Environmental Scientist
Leidos
Eglin AFB Natural Resources
107 Highway 85 North
Niceville, FL 32578
(850) 882-8395
amanda.robydek.ctr@us.af.mil

Rick Combs, Marine Scientist
Leidos
1140 Eglin Parkway
Shalimar, FL 32579
(850) 609-3459
ronald.r.combs@leidos.com

Brian Sperry, Senior Scientist
Leidos
4001 N Fairfax Dr., Suite 600
Arlington, VA 22203
(703) 907-2551
brian.j.sperry@leidos.com

This page is intentionally blank.

16.0 LITERATURE CONSIDERED AND REFERENCES CITED

Acevedo-Gutiérrez, A., D. A. Croll, and B. R. Tershy (2002). High feeding costs limit dive time in the largest whales. *Journal of Experimental Biology* 205: 1747-1753.

Afsal, V. V., P. P. Manojkumar, K. S. S. M. Yousuf, B. Anoop, and E. Vivekanandan (2009). The first sighting of Longman's beaked whale, *Indopacetus pacificus* in the southern Bay of Bengal. *Marine Biodiversity Records* 2: 1-3.

Aguayo, L. A., and T. R. Sanchez (1987). Sighting records of Fraser's dolphin in the Mexican Pacific waters. Scientific Reports of the Whales Research Institute 38: 187-188.

Aguilar, A. (2008). Fin whale *Balaenoptera physalus*. In *Encyclopedia of Marine Mammals*. W. F. Perrin, B. Wursig and J. G. M. Thewissen. Amsterdam, Academic Press**:** 433-437.

Aguilar de Soto, N., M. P. Johnson, P. T. Madsen, F. Diaz, I. Dominguez, A. Brito, and P. Tyack (2008). Cheetahs of the deep sea: Deep foraging sprints in short-finned pilot whales off Tenerife (Canary Islands). *Journal of Animal Ecology* 77(5): 936-947.

Aissi, M., A. Celona, G. Comparetto, R. Mangano, M. Wurtz, and A. Moulins (2008). Large-scale seasonal distribution of fin whales (Balaenoptera physalus) in the central Mediterranean Sea. *Journal of the Marine Biological Association of the United Kingdom* 88: 1253-1261.

Allen, B.M., and R.P. Angliss (2015). Stock Assessment Report. Humpback whale (*Megaptera novaengliea*): Central North Pacific Stock. NOAA Technical Memorandum NOAA-TM-AFSC-301. Revised 10/09/2014.

Allen, B. M., and R. P. Angliss (2014). *Alaska Marine Mammal Stock Assessments 2014*. Humpback whale (*Megaptera novaengliea*): Central North Pacific Stock. NOAA Technical Memorandum NOAA-TM-AFSC-301. Revised 10/09/2014.

Allen, B. M., and R. P. Angliss (2013). *Alaska Marine Mammal Stock Assessments 2012*. NOAA Technical Memorandum NMFS-AFSC-245, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center**:** 282.

Allen, B. M., and R. P. Angliss (2011). *Alaska Marine Mammal Stock Assessments, 2011*. (pp. 278) National Marine Mammal Laboratory Alaska Fisheries Science Center.

Allen, B. M. and R. P. Angliss (2010). *Alaska Marine Mammal Stock Assessments 2009*. Seattle, WA. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center**:** 276.

Alonso, M. K., S. N. Pedraza, A. C. M. Schiavini, R. N. P. Goodall, and E. A. Crespo (1999). Stomach contents of false killer whales (*Pseudorca crassidens*) stranded on the coasts of the Strait of Magellan, Tierra del Fuego. Marine Mammal Science 15(3): 712-724.

Alves, F., A. Dinis, I. Cascao, and L. Freitas (2010). Bryde's whale (*Balaenoptera brydei*) stable associations and dive profiles: New insights from foraging behavior. *Marine Mammal Science* 26(1): 202-212.

Anderson, R. C., R. Clark, P. T. Madsen, C. Johnson, J. Kiszka and O. Breysse (2006). Observations of Longman's beaked whale (*Indopacetus pacificus*) in the Western Indian Ocean. *Aquatic Mammals* 32(2): 223-231.

Antonelis, G. A., J. D. Baker, T. C. Johanos, R. C. Braun and A. L. Harting (2006). Hawaiian monk seal (*Monachus schauinslandi*): Status and conservation issues. *Atoll Research Bulletin* 543: 75-101.

Archer, F. I., and W. F. Perrin (1999). Stenella coeruleoalba. *Mammalian Species* 603: 1-9.

Aschettino, J.M. 2010. *Population size and structure of melon-headed whales (Peponocephala electra) around the main Hawaiian Islands: evidence of multiple populations based on photographic data*. Master's Thesis. Hawaii Pacific University.

Au, D. W. K., and W. L. Perryman (1985). Dolphin habitats in the eastern tropical Pacific. *Fishery Bulletin* 83: 623-643.

Au, W. W. L. (1993). *The Sonar of Dolphins* (pp. 277). New York, NY: Springer-Verlag.

Au, W. W. L., R. W. Floyd, R. H. Penner, and A. E. Murchison (1974). Measurement of echolocation signals of the Atlantic bottlenose dolphin, *Tursiops truncatus* Montagu, in open waters. *Journal of the Acoustical Society of America*, 56(4), 1280-1290.

Ayres, K. L., R. K. Booth, J. A. Hempelmann, K. L. Koski, C. K. Emmons, R. W. Baird, K. Balcomb-Bartok, M. B. Hanson, M. J. Ford, and S. K. Wasser (2012). Distinguishing the Impacts of Inadequate Prey and Vessel Traffic on an Endangered Killer Whale (*Orcinus orca*) Population. *PLoS ONE*:7(6), pp 12.

Azzellino, A., S. Gaspari, S. Airoldi, and B. Nani (2008). Habitat use and preferences of cetaceans along the continental slope and the adjacent pelagic waters in the western Ligurian Sea. *Deep Sea Research* I 55: 296–323.

Baird, R. W. (2006). Hawai'i's other cetaceans. *Whale and Dolphin Magazine* 11: 28-31.

Baird, R. W. (2005). Sightings of dwarf (*Kogia sima*) and pygmy (*K. breviceps*) sperm whales from the main Hawaiian Islands. *Pacific Science* 59: 461-466.

Baird, R. W. (2009a). A review of false killer whales in Hawaiian waters: Biology, status, and risk factors. Olympia, WA, *Cascadia Research Collective*: 41.

Baird, R. W. (2009b). False killer whale *Pseudorca crassidens*. In *Encyclopedia of Marine Mammals* (Second Edition). W. F. Perrin, B. Wursig and J. G. M. Thewissen, Academic Press: 405-406.

Baird, R. W., A. M. Gorgone, D. J. McSweeney, A. D. Ligon, M. H. Deakos, D. L. Webster, G. S. Schorr, K. K. Martien, D. R. Salden, and S. D. Mahaffy (2009a). Population structure of island-associated dolphins: Evidence from photo-identification of common bottlenose dolphins (*Tursiops truncatus*) in the main Hawaiian Islands. *Marine Mammal Science* 25(2): 251-274.

Baird, R. W., A. M. Gorgone, D. L. Webster, D. J. McSweeney, J. W. Durban, A. D. Ligon, D. R. Salden, and M. H. Deakos (2005a). *False Killer Whales Around the Main Hawaiian Islands: An Assessment of Interisland Movements and Population Size Using Individual Photo-Identification* (Pseudorca crassidens). Report prepared under Order No. JJ133F04SE0120 from the Pacific Islands Fisheries Science Center, National Marine Fisheries Service, 2570 Dole Street, Honolulu, HI 96822. 24pgs. 2005.

Baird, R. W., M. B. Hanson, E. E. Ashe, M. R. Heithaus, and G. J. Marshall (2003). *Studies of Foraging in "Southern Resident" Killer Whales during July 2002: Dive Depths, Bursts in Speed, and the Use of a "Crittercam" System for Examining Sub-surface Behavior*. Seattle, WA, U.S. Department of Commerce, National Marine Fisheries Service, National Marine Mammal Laboratory: 18.

Baird, R. W., A. D. Ligon, S. K. Hooker, and A. M. Gorgone (2001). Subsurface and nighttime behaviour of pantropical spotted dolphins in Hawai'i. *Canadian Journal of Zoology, 79*(6), 988-996.

Baird, R. W., S. W. Martin, D. L. Webster, and B. L. Southall (2014). *Assessment of Modeled Received Sound Pressure Levels and Movements of Satellite-Tagged Odontocetes Exposed to Mid-Frequency Active Sonar at* *the Pacific Missile Range Facility: February 2011 Through February 2013*. Prepared for U.S. Pacific Fleet, submitted to NAVFAC PAC by HDR Environmental, Operations and Construction, Inc.

Baird, R., D. McSweeney, C. Bane, J. Barlow, D. Salden, L. Antoine, R. LeDuc, and D. Webster (2006a). Killer whales in Hawaiian waters: Information on population identity and feeding habits. *Pacific Science* 60(4): 523–530.

Baird, R. W., D. J. McSweeney, G. S. Schorr, S. D. Mahaffy, D. L. Webster, J. Barlow, M. B. Hanson, J. P. Turner and R. D. Andrews (2009b). Studies of beaked whales in Hawai'i: Population size, movements, trophic ecology, social organization, and behaviour. In *Beaked Whale Research*. S. J. Dolman, C. D. MacLeod and P. G. H. Evans, European Cetacean Society**:** 23-25.

Baird, R. W., D. J. McSweeney, D. L. Webster, A. M. Gorgone, and A. D. Ligon (2003). *Studies of Odontocete Population Structure in Hawaiian Waters: Results of a Survey Through the Main Hawaiian Islands in May and June 2003*. Seattle, WA, NOAA**:** 25.

Baird, R. W., G. S. Schorr, D. L. Webster, D. J. McSweeney, M. B. Hanson, and R. D. Andrews (2010a). Movements and habitat use of satellite-tagged false killer whales around the main Hawaiian Islands. *Endangered Species Research* 10: 107-121.

Baird, R., G. Schorr, D. Webster, D. McSweeney, M. Hanson, and R. Andrews (2010b). Movements and habitat use of Cuvier's and Blainville's beaked whales in Hawaii: results from satellite tagging in 2009/2010. *C. Research*. La Jolla, CA.

Baird, R. W., G. S. Schorr, D. L. Webster, D. J. McSweeney, and S. D. Mahaffy (2006b). Studies of beaked whale diving behavior and odontocete stock structure in Hawai'i in March/April 2006**:** 31.

Baird, R. W., D. L. Webster, J. M. Aschettino, G. S. Schorr, and D. J. McSweeney (2013). Odontocete cetaceans around the main Hawaiian Islands: Habitat use and relative abundance from small-boat sighting surveys. *Aquatic Mammals* 39:253-269.

Baird, R. W., D. L. Webster, S. D. Mahaffy, D. J. McSweeney, G. S. Schorr, and A. D. Ligon (2008). Site fidelity and association patterns in a deep-water dolphin: Rough-toothed dolphins (*Steno bredanensis*) in the Hawaiian Archipelago. *Marine Mammal Science* 24(3): 535-553.

Baird, R. W., D. L. Webster, D. J. McSweeney, A. D. Ligon, and G. S. Schorr (2005b). *Diving Behavior and Ecology of Cuvier's (*Ziphius cavirostris*) and Blainville's Beaked Whales (*Mesoplodon densirostris*) in Hawai'i*. La Jolla, CA.

Baird, R. W., D. L. Webster, G. S. Schorr, J. M. Aschettino, A. M. Gorgone, and S. D. Mahaffy (2012). *Movements and Spatial Use of Odontocetes in the Western Main Hawaiian Islands: Results from Satellite-Tagging and Photo-Identification off Kauai and Niihau in July/August 2011*. Technical Report: NPS-OC-12-003CR; http://hdl.handle.net/10945/13855.

Baker, J. D. (2004). Evaluation of closed capture-recapture methods to estimate abundance of Hawaiian monk seals. *Ecological Applications* 14: 987-998.

Baker, J. D. (2008). Variation in the relationship between offspring size and survival provides insight into causes of mortality in Hawaiian monk seals. *Endangered Species Research* 5: 55-64.

Baker, J. D., and T. C. Johanos (2004). Abundance of the Hawaiian monk seal in the main Hawaiian Islands. *Biological Conservation* 116(1): 103-110.

Baker, A. N., and B. Madon (2007). Bryde's whales (Balaenoptera cf. brydei Olsen 1913) in the Hauraki Gulf and northeastern New Zealand waters. *Science for Conservation* 272: 4-14.

Baker, J. D., A. L. Harting, and T. C. Johanos (2006). Use of discovery curves to assess abundance of Hawaiian monk seals. *Marine Mammal Science* 22(4): 847-861.

Balcomb, K.C. (1987). The Whales of Hawaii, Including All Species of Marine Mammals in Hawaiian and Adjacent Waters. San Francisco: Marine Mammal Fund.

Baldwin, R. M., M. Gallagher, and K. Van Waerebeek (1999). A review of cetaceans from waters off the Arabian Peninsula. In T*he Natural History of Oman: A Festschrift for Michael Gallagher*. M. Fisher, S. A. Ghazanfur and J. A. Soalton, Backhuys Publishers**:** 161-189.

Barlow, J. (2006). Cetacean abundance in Hawaiian waters estimated from a summer/fall survey in 2002. *Marine Mammal Science* 22(2): 446-464.

Barlow, J. (2003). *Cetacean Abundance in Hawaiian Waters During Summer/Fall 2002*. La Jolla, CA, Southwest Fisheries Science Center, National Marine Fisheries Service and NOAA**:** 22.

Barlow, J., J. Calambokidis, E. A. Falcone, C. S. Baker, A. M. Burdin, P. J. Clapham, J. K. B. Ford, C. M. Gabriele, R. LeDuc, D. K. Mattila, T. J. Quinn II, L. Rojas-Bracho, J. M. Straley, B. L. Taylor, J. Urban-R, P. Wade, D. Weller, B. H, Witteveen, M. Yamaguchi (2011). Humpback whale abundance in the North Pacific estimated by photographic capture-recapture with bias correction from simulation studies. *Marine Mammal Science*, 1-26.

Barlow, J., M. Ferguson, E. Becker, J. Redfern, K. Forney, I. Vilchis, P. Fiedler, T. Gerrodette, and L. Ballance (2009). Predictive Modeling of Cetacean Densities in the Eastern Pacific Ocean. NOAA-TMNMFS-SWFSC-444, Southwest Fisheries Science Center, La Jolla, California.

Barlow, J., M. C. Ferguson, W. F. Perrin, L. Ballance, T. Gerrodette, G. Joyce (2006). Abundance and densities of beaked and bottlenose whales (family Ziphiidae). *Journal of Cetacean Research and Management* 7(3): 263-270.

Barlow, J., and R. Gisiner (2006). Mitigating, monitoring and assessing the effects of anthropogenic sound on beaked whales. *Journal of Cetacean Research and Management*, 7(3), 239-249.

Barlow, J., S. Rankin, A. Jackson, and A. Henry (2008). *Marine Mammal Data Collected During the Pacific Islands Cetacean and Ecosystem Assessment Survey (PICEAS) Conducted Aboard the NOAA Ship McArthur II, July-November 2005*, NOAA**:** 27.

Barlow, J., S. Rankin, E. Zele, and J. Appler (2004). *Marine Mammal Data Collected During the Hawaiian Islands Cetacean and Ecosystem Assessment Survey (HICEAS) Conducted Aboard the NOAA ships McArthur and David Starr Jordan, July-December 2002*, NOAA**:** 32.

Barros, N. B., and A. A. Myrberg (1987). Prey detection by means of passive listening in bottlenose dolphins (*Tursiops truncatus*). *Journal of the Acoustical Society of America* 82: S65.

Barros, N. B., and R. S. Wells (1998). Prey and feeding patterns of resident bottlenose dolphins (*Tursiops truncatus*) in Sarasota Bay, Florida. *Journal of Mammalogy* 79(3): 1045-1059.

Baumgartner, M. F. (1997). The distribution of Risso's dolphin (*Grampus griseus*) with respect to the physiography of the northern Gulf of Mexico. *Marine Mammal Science* 13(4): 614-638.

Beatson, E. (2007). The diet of pygmy sperm whales, *Kogia breviceps*, stranded in New Zealand: Implications for conservation. *Reviews in Fish Biology and Fisheries* 17: 295-303.

Becker, E.A., K.A. Forney, D.G. Foley, and J. Barlow (2012). Density and Spatial Distribution Patterns of Cetaceans in the Central North Pacific Based on Habitat Models. U.S. Department of Commerce NOAA Technical Memorandum NMFS-SWFSC-490, 34 p.

Benoit-Bird, K. J. (2004). Prey caloric value and predator energy needs: Foraging predictions for wild spinner dolphins. *Marine Biology* 145: 435-444.

Benoit-Bird, K. J., and W. W. L. Au (2003). Prey dynamics affect foraging by a pelagic predator (*Stenella longirostris*) over a range of spatial and temporal scales. *Behavioral Ecology and Sociobiology* 53: 364-373.

Benoit-Bird, K. J., and W. W. L. Au (2004). Diel migration dynamics of an island-associated sound scattering layer. *Deep-Sea Research* I 51: 707-719.

Benoit-Bird, K. J., W. W. Au, R. E. Brainard, and M. O. Lammers (2001). Diel horizontal migration of the Hawaiian mesopelagic boundary community observed acoustically. *Marine Ecology Progress Series* 217: 1-14.

Bernard, H. J., and S. B. Reilly (1999). Pilot whales *Globicephala* Lesson, 1828. In *Handbook of Marine Mammals*. S. H. Ridgway and R. Harrison. San Diego, CA, Academic Press. 6**:** 245-280.

Berzin, A. A., and V. L. Vladimirov (1981). Changes in abundance of whalebone whales in the Pacific and Antarctic since the cessation of their exploitation. *Reports of the International Whaling Commission* 31: 495-499.

Best, P. B. (1996). Evidence of migration by Bryde's whales from the offshore population in the southeast Atlantic. *Reports of the International Whaling Commission* 46: 315-322.

Best, P. B., D. S. Butterworth, and L. H. Rickett (1984). An assessment cruise for the South African inshore stock of Bryde's whales (*Balaenoptera edeni*). *Reports of the International Whaling Commission* 34: 403-423.

Best, P. B., and C. H. Lockyer (2002). Reproduction, growth and migrations of sei whales *Balaenoptera borealis* off the west coast of South Africa in the 1960s. *South African Journal of Marine Science* 24: 111-133.

Best, P. B., R. A. Rademeyer, C. Burton, D. Ljungblad, K. Sekiguchi, H. Shimada, D. Thiele, D. Reeb, and D. S. Butterworth (2003). The abundance of blue whales on the Madagascar Plateau, December 1996. *Journal of Cetacean Research and Management* 5(3): 253-260.

Bloodworth, B., and D. K. Odell (2008). Kogia breviceps. *Mammalian Species* 819: 1-12.

Boggs, C. H., E. M. Oleson, K. A. Forney, B. Hanson, D. R. Kobayashi, B. L. Taylor, and G. M. Ylitalo (2010). *Status Review of Hawaiian Insular False Killer Whales (*Pseudorca crassidens*) Under the Endangered Species Act*. NOAA Technical Memorandum NMFS-PIFSC-22, pp. 140 + appendices. U. S. Department of Commerce and National Oceanic and Atmospheric Administration.

Bolle, L. J., C. A. F. de Jong, S. M. Bierman, P. J. G. van Beek, and O.A. van Keken, 2012. Common sole larvae survive high levels of pile-driving sound in controlled exposure experiments. *PLoS ONE* 7(3): e33052. doi:10.1371/journal.pone.0033052.

Bradford, A. L., K. A. Forney, E. M. Oleson, and J. Barlow (2012). *Line-Transect Abundance Estimates of False Killer Whales (*Pseudorca crassidens*) in the Pelagic Region of the Hawaiian Exclusive Economic Zone and in the Insular Waters of the Northwestern Hawaiian Islands*. Pacific Islands Fisheries Science Center, National Marine Fisheries Service, NOAA, Honolulu, HI 96822-2396. Pacific Islands Fish. Sci. Cent. Admin. Rep. H-12-02.

Bradford, A. L., K. A. Forney, E. M. Oleson, and J. Barlow (in review). Line-transect abundance estimates of cetaceans in the Hawaiian EEZ**.** *Fisheries Bulletin*.

Bradford. A. L., K. A. Forney, E. M. Oleson, and J. Barlow (2013). Line-Transect Abundance Estimates of Cetaceans in the Hawaiian EEZ. PIFSC Working Paper WP-13-004.

Bradford, A. L., and E. Lyman (2015). *Injury Determinations for Humpback Whales and Other Cetaceans Reported to NOAA Response Networks in the Hawaiian Islands During 2007-2012*. U.S. Department of Commerce, NOAA Technical Memoranda, NOAA-TM-NMFS-PIFSC-45, 29p.

Bradford, A. L., E. M. Oleson, R. W. Baird, C. H. Boggs, K. A. Forney, and N. C. Young (2015). *Revised Stock Boundaries for False Killer Whales (*Pseuorca crassidens*) in Hawaiian Waters*. NOAA Technical Memorandum NMFS-PIFSC-47. September 2015.

Brillinger, D. R., B. S. Stewart, and C. S. Littnan (2006). A meandering *hylje**. In Festschrift for Tarmo Pukkila on his 60th Birthday. E. P. Liski, J. Isotalo, J. Niemelä, S. Puntanen and G. P. H. Styan. Finland, Dept. of Mathematics, Statistics and Philosophy, University of Tampere**:** 79-92.

Brownell R. L., Jr, K. Ralls, S. Baumann-Pickering, and M. M. Poole (2009). Behavior of melon-headed whales, *Peponocephala electra*, near oceanic islands. *Marine Mammal Science* 25(3): 639-658.

Bull, J. C., P. D. Jepson, R. K. Ssuna, R. Deaville, C. R. Allchin, R. J. Law, and A. Fenton (2006). The relationship between polychlorinated biphenyls in blubber and levels of nematode infestations in harbour porpoises, *Phocoena phocoena*. *Parasitology*, 132, 565-573. doi:10.1017/S003118200500942X.

Calambokidis, J. (2009). Symposium on the Results of the SPLASH Humpback Whale Study: Final Report and Recommendations**:** 68.

Calambokidis, J., E. A. Falcone, T. J. Quinn, A. M. Burdin, P. J. Clapham, J. K. B. Ford, C. M. Gabriele, R. LeDuc, D. Mattila, L. Rojas-Bracho, J. M. Straley, B. L. Taylor, J. Urban-R, D. Weller, B. H. Witteveen, M. Yamaguchi, A. Bendlin, D. Camacho, K. Flynn, A. Havron, J. Huggins, N. Maloney, J. Barlow, and P. R. Wade (2008). *SPLASH: Structure of Populations, Levels of Abundance and Status of Humpback Whales in the North Pacific.* Final report for Contract AB133F-03-RP-00078 prepared by Cascadia Research for U.S. Dept of Commerce.

Calambokidis, J., G. H. Steiger, J. M. Straley, S. Cerchio, D. R. Salden, J. Urban-R, J. K. Jacobsen, O. von Ziegesar, K. C. Balcomb, C. M. Gabriele, M. E. Dahlheim, S. Uchida, G. Ellis, Y. Miyamura, P. Ladron De Guevara, M. Yamaguchi, F. Sato, S. A. Mizroch, L. Schlender, K. Rasmussen, J. Barlow, and T. J. Quinn II (2001). Movements and population structure of humpback whales in the North Pacific. *Marine Mammal Science* 17(4): 769-794.

Caldwell, D. K., and M. C. Caldwell (1989). Pygmy sperm whale *Kogia breviceps* (de Blainville, 1838): Dwarf sperm whale *Kogia simus* Owen, 1866. In *Handbook of Marine Mammals*. S. H. Ridgway and R. Harrison. San Diego, CA, Academic Press. 4: 234-260.

Canadas, A., R. Sagarminaga, and S. Garcia-Tiscar (2002). Cetacean distribution related with depth and slope in the Mediterranean waters off southern Spain. *Deep Sea Research* I 49: 2053-2073.

Canese, S., A. Cardinali, C. M. Forunta, M. Giusti, G. Lauriano, E. Salvati, and S. Greco (2006). The first identified winter feeding ground of fin whales (Balaenoperta physalus) in the Mediterranean Sea. *Journal of the Marine Biological Association of the United Kingdom* 86(4): 903-907.

Carretta, J. V., K. A. Forney, E. Oleson, K. Martien, M. M. Muto, M. S. Lowry, J. Barlow, J. Baker, B. Hanson, D. Lynch, L. Carswell, R. L. Brownell, J. Robbins, D. K. Mattila, K. Ralls, and M. C. Hill (2011). *U.S. Pacific Marine Mammal Stock Assessments: 2010*. La Jolla, CA, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center**:** 352.

Carretta, J. V., K. A. Forney, M. S. Lowry, J. Barlow, J. Baker, D. Johnston, B. Hanson, R. L. Brownell, Jr., J. Robbins, D. Mattila, K. Ralls, M. M. Muto, D. Lynch, and L. Carswell (2010). *U.S. Pacific Marine Mammal Stock Assessments: 2009. La Jolla, CA, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center: 336.*

Carretta, J.V., E. M. Oleson, D. W. Weller, A. R. Lang, K. A. Forney, J. Baker, M. M. Muto, B. Hanson, A. J. Orr, H. Huber, M. S. Lowry, J. Barlow, J. E. Moore, D. Lynch, L. Carswell, and R. L. Brownell Jr. (2015). *U.S. Pacific Marine Mammal Stock Assessments: 2014*. U.S. Department of Commerce, NOAA Technical Memorandum, NOAA-TMNMFS-SWFSC-549. 414 p.

Carretta, J. V., T. Price, D. Petersen, and R. Read (2005). Estimates of marine mammal, sea turtle, and seabird mortality in the California drift gillnet fishery for swordfish and thresher shark, 1996-2002. *Marine Fisheries Review* 66(2): 21-30.

Cascadia Research (2010). *Hawai'i's false killer whales*.

Cascadia Research (2012a). An Update on Our June/July 2012 Kaua'i Field Work. Cascadia Research Collective. http://www.cascadiaresearch.org/hawaii/july2011.htm.

Cascadia Research (2012b). Beaked Whales in Hawai'i. Cascadia Research. http://www.cascadiaresearch.org/hawaii/beakedwhales.htm.

Cetacean and Turtle Assessment Program (1982). *A Characterization of Marine Mammals and Turtles in the Mid- and North Atlantic Areas of the U.S. Outer Continental Shelf*. 540.

Chivers, S. J., R. W. Baird, K. M. Martien, B. L. Taylor, E. Archer, A. M. Gorgone, B. L. Hancock, N. M. Hedrick, D. Matilla, D. J. McSweeney, E. M. Oleson, C. L. Palmer, V. Pease, K. M. Robertson, J. Robbins, J. C. Salinas, G. Schorr, M. Schultz, J. L. Thieleking, and D. L. Webster (2010). *Evidence of Genetic Differentiation for Hawaii Insular False Killer Whales (*Pseudorca crassidens). NOAA Technical Report NMFS NOAA-TM-NMFS-SWFSC-458: 49.

Chivers, S. J., R. W. Baird, D. J. McSweeney, D. L. Webster, N. M. Hedrick, and J. C. Salinas (2007). Genetic variation and evidence for population structure in eastern North Pacific false killer whales (*Pseudorca crassidens*). *Canadian Journal of Zoology* 85: 783-794.

Clapham, P. J. (2000). The humpback whale: seasonal feeding and breeding in a baleen whale. In *Cetacean Societies: Field Studies of Dolphins and Whales*. J. Mann, R. C. Connor, P. L. Tyack and H. Whitehead, University of Chicago Press**:** 173-196.

Clapham, P. J., and D. K. Mattila (1990). Humpback whale songs as indicators of migration routes. *Marine Mammal Science* 6(2): 155-160.

Clapham, P. J., and J. G. Mead (1999). *Megaptera novaeangliae*. *Mammalian Species* 604: 1-9.

Clarke, M. R. (1996). Cephalopods as prey. III. Cetaceans. Philosophical Transactions of the Royal Society of London 351: 1053-1065.

Cox, T., T. Ragen, A. Read, E. Vox, R. Baird, K. Balcomb, L. Benner (2006). Understanding the impacts of anthropogenic sound on beaked whales. *Journal of Cetacean Research and Management*, 7(3), 177-187.

Craig, A. S., and L. M. Herman (2000). Habitat preferences of female humpback whales Megaptera novaeangliae in the Hawaiian Islands are associated with reproductive status. *Marine Ecology Progress Series* 193: 209-216.

Cummings, W. C. (1985). Bryde's whale *Balaenoptera edeni* Anderson, 1878. In *Handbook of Marine Mammals*. S. H. Ridgway and R. Harrison. San Diego, CA, Academic Press. 3**:** 137-154.

D'Vincent, C. G., R. M. Nilson, and R. E. Hanna (1985). Vocalization and coordinated feeding behavior of the humpback whale in southeastern Alaska. *Scientific Reports of the Whales Research Institute* 36: 41-47.

Dahlheim, M. E., and J. E. Heyning (1999). Killer whale *Orcinus orca* (Linnaeus, 1758). In *Handbook of Marine Mammals.* S. H. Ridgway and R. Harrison. San Diego, CA, Academic Press. 6**:** 281-322.

Dalebout, M. L., J. G. Mead, C. S. Baker, A. N. Baker, and A. L. van Helden (2002). A new species of beaked whale *Mesoplodon perrini* sp. n. (Cetacea: Ziphiidae) discovered through phylogenetic analyses of mitochondrial DNA sequences. *Marine Mammal Science* 18(3): 577-608.

Dalebout, M. L., G. J. B. Ross, C. S. Baker, R. C. Anderson, P. B. Best, V. G. Cockcroft, H. L. Hinsz, V. M. Peddemors, and R. L. Pitman (2003). Appearance, distribution and genetic distinctiveness of Longman's beaked whale, *Indopacetus pacificus*. *Marine Mammal Science* 19(3): 421-461.

Davis, R. W., W. E. Evans, and B. Wursig (2000). *Cetaceans, Sea Turtles and Seabirds in the Northern Gulf of Mexico: Distribution, Abundance and Habitat Associations. Volume II: Technical report*. New Orleans, LA, U.S. Department of the Interior, Geological Survey, Biological Resources Division, and Minerals Management Service, Gulf of Mexico OCS Region**:** 346.

Davis, R. W., G. S. Fargion, N. May, T. D. Leming, M. Baumgartner, W. E. Evans, L. J. Hansen, and K. Mullin (1998). Physical habitat of cetaceans along the continental slope in the north-central and western Gulf of Mexico. *Marine Mammal Science* 14(3): 490-507.

Davis, R. W., N. Jaquet, D. Gendron, U. Markaida, G. Bazzino, and W. Gilly (2007). Diving behavior of sperm whales in relation to behavior of a major prey species, the jumbo squid, in the Gulf of California, Mexico. *Marine Ecology Progress Series* 333: 291-302.

Debusschere, Elisabeth, Kris Hostens, Dominique Adriaens, Bart Ampe, Dick Botteldooren, Gadrun De Boeck, Amelie De Muynck, Amit Kumar Sinha, Sofie Vandendriessche, Luc Van Hoorebeke, Magda Vincx, and Steven Degraer (2015). Acoustic stress responses in juvenile sea bass Dicentrarchus labrax induced by offshore pile driving. *Environmental Pollution* 208 (2016) 747-757.

Dolar, M. L. L. (2008). Fraser's dolphin *Lagenodelphis hosei*. In *Encyclopedia of Marine Mammals*. W. F. Perrin, B. Würsig and J. G. M. Thewissen. San Diego, CA, Academic Press**:** 485-487.

Donohue, M. J., and D. G. Foley (2007). Remote sensing reveals links among the endangered Hawaiian monk seal, marine debris and El Niño. *Marine Mammal Science* 23(2): 468–473.

Donahue, M. A., and W. L. Perryman (2008). Pygmy killer whale *Feresa attenuata*. In *Encyclopedia of Marine Mammals*. W. F. Perrin, B. Würsig and J. G. M. Thewissen. San Diego, CA, Academic Press: 938-939.

Donovan, G. P. (1991). A review of IWC stock boundaries. *Reports of the International Whaling Commission Special Issue* 13: 39-68.

Dunphy-Daly, M. M., M. R. Heithaus, and D. E. Claridge (2008). Temporal variation in dwarf sperm whale (*Kogia sima*) habitat use and group size off Great Abaco Island, Bahamas. *Marine Mammal Science* 24(1): 171-182.

Edds-Walton, P. L. (1997). Acoustic communication signals of mysticete whales. *Bioacoustics: The International Journal of Animal Sound and Its Recording*, 8, 47-60.

Erbe C., A. MacGillivray, and R. Williams (2012). Mapping cumulative noise from shipping to inform marine spatial planning. *Journal of the Acoustical Society of America*, 132(5): 423-428.

Ersts, P. J., and H. C. Rosenbaum (2003). Habitat preference reflects social organization of humpback whales (Megaptera novaeangliae) on a wintering ground. *Journal of Zoology*, London 260: 337-345.

Fair, P. A., J. Adams, G. Mitchum, T. C. Hulsey, J. S. Reif, M. Houde, G. D. Bossart (2010). Contaminant blubber burdens in Atlantic bottlenose dolphins (*Tursiops truncatus*) from two southeastern US estuarine areas:

Concentrations and patterns of PCBs, pesticides, PBDEs, PFCs, and PAHs. *Science of the Total Environment, 408*, 1577-1597. doi:10.1016/j.scitotenv.2009.12.021.

Falcone, E., G. Schorr, A. Douglas, J. Calambokidis, E. Henderson, M. McKenna, J. Hildebrand, and D. Moretti (2009). Sighting characteristics and photo-identification of Cuvier's beaked whales (*Ziphius cavirostris*) near San Clemente Island, California: A key area for beaked whales and the military? *Marine Biology* 156: 2631-2640.

Fauquier, D. A., M. J. Kinsel, M. D. Dailey, G. E. Sutton, M. K. Stolen, R. S. Wells, and F. M. D. Gulland (2009). Prevalence and pathology of lungworm infection in bottlenose dolphins Tursiops truncatus from southwest Florida. *Diseases of Aquatic Organisms*, 88, 85-90. doi: 10.3354/dao02095.

Ferguson, M. C. (2005). *Cetacean Population Density in the Eastern Pacific Ocean: Analyzing Patterns With Predictive Spatial Models.* University of California, San Diego.

Ferguson, M. C., J. Barlow, T. Gerrodette, and P. Fiedler (2001). Meso-Scale Patterns in the Density and Distribution of Ziphiid Whales in the Eastern Pacific Ocean. Fourteenth Biennial Conference on the Biology of Marine Mammals, Vancouver, British Columbia.

Ferguson, M. C., J. Barlow, S. B. Reilly, and T. Gerrodette (2006). Predicting Cuvier's (*Ziphius cavirostris*) and *Mesoplodon* beaked whale population density from habitat characteristics in the eastern tropical Pacific Ocean. *Journal of Cetacean Research and Management* 7(3): 287-299.

Fertl, D., A. Acevedo-Guiterrez, and F. L. Darby (1996). A report of killer whales (*orcinus orca*) feeding on a carcharhinid shark in Costa Rica. *Marine Mammal Science* 12(4):606-611. October 1996.

Finneran, J. J., D. A. Carder, C. E. Schlundt, and S. H. Ridgway (2005). temporary threshold shift in bottlenose dolphins (*Tursiops truncatus*) exposed to mid-frequency tones. *Journal of the Acoustical Society of America* 118:2696-2705.

Finneran, J. J., and A. K. Jenkins (2012). Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis. U.S. Navy, SPAWAR Systems Center. April.

Finneran, J. J., and C. E. Schlundt (2004). *Effects of Intense Pure Tones on the Behavior of Trained Odontocetes* [Technical Report]. (Vol. TR 1913). San Diego, California: SSC San Diego.

Finneran, J. J., and C. E. Schlundt (2009). Auditory Weighting Functions and Frequency-Dependent Effects of Sound in Bottlenose Dolphins (*Tursiops truncatus*). Alexandria, Virginia, 2009 ONR Marine Mammal Program Review.

Ford, J. K. B. (2008). Killer whale *Orcinus orca*. In *Encyclopedia of Marine Mammals*. W. F. Perrin, B. Würsig and J. G. M. Thewissen. San Diego, CA, Academic Press**:** 650-657.

Ford, J. K. B., G. M. Ellis, D. R. Matkin, K. C. Balcomb, D. Briggs, and A. B. Morton (2005). Killer whale attacks on minke whales: Prey capture and antipredator tactics. *Marine Mammal Science* 21(4):603-618.

Ford, J. K. B., G. M. Ellis, P. F. Olesiuk, and K. C. Balcomb (2009). Linking killer whale survival and prey abundance: food limitation in the oceans' apex predator. *Biol. Lett*.

Forestell, P. H., and J. Urbán-Ramirez (2007). Movement of a humpback whale (*Megaptera novaeangliae*) between the Revillagigedo and Hawaiian Archipelagos within a winter breeding season. *LAJAM* 6(1): 97-102.

Forney, K.A., E.A. Becker, D.G. Foley, J. Barlow, and E.M. Oleson (2015). Habitat-based models of cetacean density and distribution in the central North Pacific. *Endangered Species Research* 27: 1-20.

Forney, K., R. Baird, and E. Oleson (2010). Rationale for the 2010 Revision of Stock Boundaries for the Hawai'i Insular and Pelagic Stocks of False Killer Whales, *Pseudorca crassidens*. NOAA Technical Memorandum, NOAA-TM-NMFS-SWFSC-471.

Frantzis, A., J. C. Goold, E. K. Skarsoulis, M. I. Taroudakis, and V. Kandia (2002). Clicks from Cuvier's beaked whales, *Ziphius cavirostris* (L). *Journal of the Acoustical Society of America* 112(1): 34-37.

Fulling, G. L., P. H. Thorson, and J. Rivers (2011). Distribution and abundance estimates for cetaceans in the waters off Guam and the Commonwealth of the Northern Mariana Islands. Official Journal of the Pacific Science Association, In press Pacific Science, 1-46.

Fulling, G. L., K. D. Mullin, and C. W. Hubard (2003). Abundance and distribution of cetaceans in outer continental shelf waters of the U.S. Gulf of Mexico. Fishery Bulletin 101: 923-932.

Gallo-Reynoso, J. P., and A. L. Figueroa-Carranza (1995). Occurrence of bottlenose whales in the waters of Isla Guadalupe, Mexico. Marine Mammal Science 11(4): 573-575.

Gannier, A. (2000). Distribution of cetaceans off the Society Islands (French Polynesia) as obtained from dedicated surveys. Aquatic Mammals 26(2): 111-126.

Gannier, A., and E. Praca (2007). SST fronts and the summer sperm whale distribution in the north-west Mediterranean Sea. Journal of the Marine Biological Association of the United Kingdom 87: 187-193.

Gannier, A., and K. L. West (2005). Distribution of the rough-toothed dolphin (*Steno bredanensis*) around the Windward Islands, (French Polynesia). Pacific Science 59: 17-24.

Geijer, C. K. A., and A. J. Read (2013). Mitigation of marine mammal bycatch in U.S. fisheries since 1994. Biological Conservation 159:54-60.

Gilmartin, W. G., and J. Forcada (2009). Monk seals *Monachus monachus, M. tropicalis*, and *M. schauinslandi*. In. Encyclopedia of Marine Mammals. W. F. Perrin, B. Wursig and J. G. M. Thewissen, Academic Press**:** 741-744.

Goertner, J. F. (1982). *Prediction of Underwater Explosion Safe Ranges for Sea Mammals*. Naval Surface Weapons Center, Dahlgren, Virginia. NSWC TR 82-188.

Goldbogen, J. A., J. Calambokidis, R. E. Shadwick, E. M. Oleson, M. A. McDonald, and J. A. Hildebrand (2006). Kinematics of foraging dives and lunge-feeding in fin whales. *Journal of Experimental Biology* 209: 1231-1244.

Goodman-Lowe, G. D. (1998). Diet of the Hawaiian monk seal (*Monachus schauinslandi*) from the Northwestern Hawaiian Islands during 1991-1994. *Marine Biology*. 132**:** 535-546.

Green, G. A., J. J. Brueggeman, R. A. Grotefendt, C. E. Bowlby, M. L. Bonnell, and K. C. Balcomb III (1992). *Cetacean Distribution and Abundance off Oregon and Washington, 1989-1990*. Los Angeles, CA, Minerals Management Service**:** 100.

Green, D. M., H. DeFerrari, D. McFadden, J. Pearse, A. Popper, W. J. Richardson, P. Tyack (1994). *Low-Frequency Sound and Marine Mammals: Current Knowledge and Research Needs* (pp. 1-75). Washington, DC: Ocean Studies Board, Commission on Geosciences, Environment, and Resources, National Research Council.

Gregr, E. J., and A. W. Trites (2001). Predictions of critical habitat for five whale species in the waters of coastal British Columbia. *Canadian Journal of Fisheries and Aquatic Sciences* 58: 1265-1285.

Griffin, R. B., and N. J. Griffin (2004). Temporal variation in Atlantic spotted dolphin (*Stenella frontalis*) and bottlenose dolphin (*Tursiops truncatus*) densities on the west Florida continental shelf. *Aquatic Mammals* 30(3): 380-390.

Hamer, D. J., S. J. Childerhouse, and N. J. Gales (2010). *Mitigating Operational Interactions Between Odontocetes and the Longline Fishing Industry: A Preliminary Global Review of the Problem and of Potential Solutions*. Tasmania, Australia, International Whaling Commission: 30.

Handley, C. O. (1966). A synopsis of the genus *Kogia* (pygmy sperm whales). In *Whales, Dolphins, and Porpoises*. K. S. Norris, University of California Press: 62-69.

Hawaiian Islands Humpback Whale National Marine Sanctuary (2014). Hawaiian Islands Disentanglement Network. 2013-2014 Disentanglement Season Summary. Accessed at http://hawaiihumpbackwhale.noaa.gov/res/2014_disentanglement.html. Revised May 8, 2014.

HDR (2012). *Summary Report: Compilation of Visual Survey Effort and Sightings for Marine Species Monitoring in the Hawaii Range Complex, 2005-2012*. Prepared for Commander, U.S. Pacific Fleet, Pearl Harbor, Hawaii. Submitted to Naval Facilities Engineering Command Pacific (NAVFAC), EV2 Environmental Planning, Pearl Harbor, Hawaii, 96860-3134, under contract # N62470-10-D-3011, issued to HDR, Inc., San Diego, California, 92123.

Herman, L. M., C. S. Baker, P. H. Forestell, and R. C. Antinoja (1980). Right Whale *Balaena glacialis* Sightings near Hawaii: A Clue to the Wintering Grounds? *Marine Ecology - Progress Series*, 2, 271-275.

Heyning, J. E. (1989). Cuvier's beaked whale *Ziphius cavirostris* G. Cuvier, 1823. In *Handbook of Marine Mammals*. S. H. Ridgway and R. Harrison. San Diego, CA, Academic Press. 4**:** 289-308.

Heyning, J. E., and J. G. Mead (2008). Cuvier's beaked whale *Ziphius cavirostris*. In *Encyclopedia of Marine Mammals*. W. F. Perrin, B. Wursig and J. G. M. Thewissen, Academic Press**:** 294-295.

Hickmott, L. S. (2005). Diving Behaviour and Foraging Behaviour and Foraging Ecology of Blainville's and Cuvier's Beaked Whales in the Northern Bahamas. Master of Research in Environmental Biology Master's thesis, University of St. Andrews.

Hildebrand, J. A. (2009). Anthropogenic and natural sources of ambient noise in the ocean. *Marine Ecology Progress Series*, vol. 395: 5-20.

Hill, M. C., A. L. Bradford, K. R. Andrews, R. W. Baird, M. H. Deakos, S. D. Johnston, D. W. Mahaffy, A. J. Milette, E. M. Oleson, J. Östman-Lind, A. A. Pack, S. H. Rickards, and S. Yin (2011). *Abundance and Movements of Spinner Dolphins off the Main Hawaiian Islands*. Pacific Islands Fisheries Science Center Working Paper WP-11-013.

Hoelzel, A. R., E. M. Dorsey, and S. J. Stern (1989). The foraging specializations of individual minke whales. *Animal Behavior* 38:786-794.

Hoelzel, A. R., J. Hey, M. E. Dahlheim, C. Nicholson, V. Burkanov, and N. Black (2007). Evolution of population structure in a highly social top predator, the killer whale. *Molecular Biology and Evolution* 24(6):1407-1415.

Horwood, J. (1987). *The Sei Whale: Population Biology, Ecology, and Management*. New York, NY, Croom Helm**:** 375.

Horwood, J. (2009). Sei whale *Balaenoptera borealis*. In *Encyclopedia of Marine Mammals*. W. F. Perrin, B. Wursig and J. G. M. Thewissen. San Diego, CA, Academic Press**:** 1001-1003.

Houser, D. S., L. A. Dankiewicz-Talmadge, T. K. Stockard, and P. J. Ponganis (2010). Investigation of the potential for vascular bubble formation in a repetitively diving dolphin. *The Journal of Experimental Biology*, 213, 52-62.

Houser, D. S., J. J. Finneran, S. H. Ridgway (2010). Research with Navy marine mammals benefits animal care, conservation and biology. *International Journal of Comparative Psychology*, 23, 249-268.

Hui, C. A. (1985). Undersea topography and the comparative distribution of two pelagic cetaceans. *Fishery Bulletin* 83: 472-475.

Jefferson, T. A. (2009). Rough-toothed dolphin Steno bredanensis. In W. F. Perrin, B. Wursig & J. G. M. Thewissen (Eds.), *Encyclopedia of Marine Mammals* (Second Edition) (pp. 990-992): Academic Press.

Jefferson, T. A., and N. B. Barros (1997). *Peponocephala electra*. *Mammalian Species* 553: 1-6.

Jefferson, T. A., and S. Leatherwood (1994). *Lagenodelphis hosei*. *Mammalian Species* 470: 1-5.

Jefferson, T. A., M. A. Webber, and R. L. Pitman (2015). *Marine Mammals of the World: A Comprehensive Guide to their Identification*. Second Edition. London, UK, Elsevier: 608 p.

Jepson, P., P. Bennett, R. Deaville, C. R. Allchin, J. Baker, and R. Law (2005). Relationships between polychlorinated biphenyls and health status in harbor porpoises (*Phocoena phocoena*) stranded in the United Kingdom. *Environmental Toxicology and Chemistry*, 24(1), 238-248.

Johanos, T. C., A. L. Harting, T. L. Wurth, and J. D. Baker (2015). *Range-Wide Patterns in Hawaiian Monk Seal Movements Among Islands and Atolls*. U.S. Department of Commerce, NOAA Technical Memorandum, NOAA-TM NMFS-PIFSC-44, 26 p. doi:10.7289/V5FT8J02.

Johnson, C. S. (1967). *Sound Detection Thresholds in Marine Mammals. Marine Bioacoustics*. W. N. Tavolga. Oxford, Pergamon Press: 247-260.

Kanda, N., M. Goto, H. Kato, M. V. McPhee, and L. A. Pastene (2007). Population genetic structure of Bryde's whales (*Balaenoptera brydei*) at the inter-oceanic and trans-equatorial levels. *Conservative Genetics* 8(4): 853-864.

Kastak, D., and R. J. Schusterman (1998). 'Low-frequency amphibious hearing in pinnipeds: methods, measurements, noise, and ecology,' ***J. Acoust. Soc. Am.*** 103, 2216–2228.

Kastak, D., and R. J. Schusterman (1999). In-air and underwater hearing sensitivity of a northern elephant seal (*Mirounga angustirostris*). *Canadian Journal of Zoology*, 77, 1751-1758.

Kastelein, R. A., R. Gransier, L. Hoek, A. Macleod, and J. M. Terhune (2012). Hearing threshold shifts and recovery in harbor seals (*Phoca vitulina*) after octave-band noise exposure at 4 kHz. *Journal of the Acoustical Society of America*, 132(4), 2745-2761.

Kastelein, R. A., M. Hagedoorn, W. W. L. Au, and D. de Haan (2003). Audiogram of a striped dolphin (*Stenella coeruleoalba*). *Journal of the Acoustic Society of America* 113 (2), February 2003.

Kastelein, R. A., P. J. Wensveen, L. Hoek, W. C. Verboom, and J. M. Terhune (2009). Underwater detection of tonal signals between 0.125 and 100 kHz by harbor seals (*Phoca vitulina*). *Journal of the Acoustical Society of America* 125, 1222-1229.

Kato, H., and W. F. Perrin (2008). Bryde's whales *Balaenoptera edeni/brydei*. In *Encyclopedia of Marine Mammals*. W. F. Perrin, B. Wursig and J. G. M. Thewissen. San Diego, CA, Academic Press**:** 158-163.

Katsumata, E., K. Ohishi, and T. Maruyama (2004). Rehabilitation of a rescued pygmy sperm whale stranded on the Pacific coast of Japan. *IEEE Journal*: 488-491.

Keck, N., O. Kwiatek, F. Dhermain, F. Dupraz, H. Boulet, C. Danes, C. Laprie, A. Perrin, J. Godenir, L. Micout, and G. Libeau (2010). Resurgence of Morbillivirus infection in Mediterranean dolphins off the French coast. *The Veterinary Record* 166(21): 654-655.

Keevin, T. M., and G. L. Hempen (1997). *The Environmental Effects of Underwater Explosions with Methods to Mitigate Impacts.* U.S. Army Corps of Engineers, St. Louis District.

Kemp, N. J. (1996). Habitat loss and degradation. In *The Conservation of Whales and Dolphins*. M. P. Simmonds and J. Lagerquist, B. A., B. R. Mate, J. G. Ortega-Ortiz, M. Winsor, and J. Urban-Ramirez (2008). Migratory movements and surfacing rates of humpback whales (*Megaptera novaeangliae*) satellite tagged at Socorro Island, Mexico. Marine Mammal Science, 24(4): 815–830. D. Hutchinson. New York, NY, John Wiley & Sons**:** 476.

Kenney, R. D., and H. E. Winn (1987). Cetacean biomass densities near submarine canyons compared to adjacent shelf/slope areas. *Continental Shelf Research* **7**: 107-114.

Ketten, D. (1997). Structure and function in whale ears. *Bioacoustics* 8: 103-135.

Ketten, D. R., J. Lien, and S. Todd (1993). Blast injury in humpback whale ears: Evidence and implications. *Journal of the Acoustical Society of America* 94(3 Part 2):1849-1850.

Kishiro, T. (1996). Movements of marked Bryde's whales in the western North Pacific. Reports of the International Whaling Commission 46: 421-428.

Kjeld, M., O. Ólafsson, G. Víkingsson, and J. Sigurjónsson (2006). Sex hormones and reproductive status of the North Atlantic fin whales (*Balaenoptera physalus*) during the feeding season. *Aquatic Mammals* 32(1): 75-84.

Krahn, M. M., M. J. Ford, W. F. Perrin, P. R. Wade, R. P. Angliss, M. B. Hanson, B. L. Taylor, G. M. Ylitalo, M. E. Dahlheim, J. E. Stein, and R. S. Waples (2004). *2004 Status Review of Southern Resident Killer Whales (Orcinus orca) under the Endangered Species Act*. Seattle, WA, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northwest Fisheries Science Center**:** 73.

Kruse, S., D. K. Caldwell, and M. C. Caldwell (1999). Risso's dolphin *Grampus griseus* (G. Cuvier, 1812). In *Handbook of Marine Mammals*. S. H. Ridgway and R. Harrison. San Diego, CA, Academic Press. 6**:**183-212.

Kuker, K. J., J. A. Thomson, and U. Tscherter (2005). Novel surface feeding tactics of minke whales, *Balaenoptera acutorostrata*, in the Saguenay-St. Lawrence National Marine Park. *Canadian Field-Naturalist* 119(2): 214-218.

Lagerquist, B. A., B. R. Mate, J. G. Ortega-Ortiz, M. Winsor, and J. Urban-Ramirez (2008). Migratory movements and surfacing rates of humpback whales (*Megaptera novaeangliae*) satellite tagged at Socorro Island, Mexico. *Marine Mammal Science*, 24(4): 815–830.

Laist, D. W. (1997). Impacts of marine debris: Entanglement of marine life in marine debris including a comprehensive list of species with entanglement and ingestion records. In J. M. Coe and D. B. Rogers (Eds.), *Marine Debris: Sources, Impacts, and Solutions* (pp. 99-140). New York, NY: Springer-Verlag.

Lammers, M. O. (2004). Occurrence and behavior of Hawaiian spinner dolphins (*Stenella longirostris*) along Oahu's leeward and south shores. *Aquatic Mammals* 30(2): 237-250.

Lammers, M. O., P. I. Fisher-Pool, W. W. L. Au, C. G. Meyer, K. B. Wong, R. E. Brainard (2011). Humpback whale *Megaptera novaeangliae* song reveals wintering activity in the Northwestern Hawaiian Islands. *Marine Ecology Progress Series*, 423: 261–268.

Leatherwood, S., W. F. Perrin, V. L. Kirby, C. L. Hubbs, and M. Dahlheim (1980). Distribution and movements of Risso's dolphin, *Grampus griseus*, in the eastern North Pacific. *Fishery Bulletin* 77(4): 951-963.

Leslie, M. S., A. Batibasaga, D. S. Weber, D. Olson, and H. C. Rosenbaum (2005). First record of Blainville's beaked whale *Mesoplodon densirostris* in Fiji. *Pacific Conservation Biology* 11(4): 302-304.

Lindstrom, U., and T. Haug (2001). Feeding strategy and prey selectivity in common minke whales (*Balaenoptera acutorostrata*) foraging in the southern Barents Sea during early summer. *Journal of Cetacean Research and Management* 3(3): 239-250.

Littnan, C. (2011). *Habitat Use and Behavioral Monitoring of Hawaiian Monk Seals in Proximity to the Navy Hawaii Range Complex. Report Period: August 2010-July 2011.* Appendix M, HRC annual monitoring report for 2011, submitted to National Marine Fisheries Service.

Littnan, C. (2012). *Habitat Use and Behavioral Monitoring of Hawaiian Monk Seals in Proximity to the Navy Hawaii Range Complex*. Report Period: July 2011-June 2012.

Littnan, C. L., B. S. Stewart, P. K. Yochem, and R. Braun (2007). Survey of selected pathogens and evaluation of disease risk factors for endangered Hawaiian monk seals in the main Hawaiian Islands. *EcoHealth* 3: 232–244.

Lodi, L., and B. Hetzel (1999). Rough-toothed dolphin, *Steno bredanensis*, feeding behaviors in Ilha Grande Bay, Brazil. *Biociências* 7(1): 29-42.

Lusseau, D., D. E. Bain, R. Williams, and J. C. Smith (2009). Vessel traffic disrupts the foraging behavior of southern resident killer whales *Orcinus orca*. *Endangered Species Research* 6: 211–221.

Lusseau, D., and L. Bejder (2007). The long-term consequences of short-term responses to disturbance experiences from whalewatching impact assessment. *International Journal of Comparative Psychology*, 20(2), 228-236. Retrieved from http://escholarship.org/uc/item/42m224qc.

MacLeod, C. D., and A. D'Amico (2006). A review of beaked whale behaviour and ecology in relation to assessing and mitigating impacts of anthropogenic noise. *Journal of Cetacean Research and Management* **7**(3): 211-222.

MacLeod, C. D., N. Hauser, and H. Peckham (2003). Review of data on diets of beaked whales: evidence of niche separation and geographic segregation. *Journal of the Marine Biological Association of the United Kingdom* 83: 651-665.

MacLeod, C. D., N. Hauser, and H. Peckham (2004). Diversity, relative density and structure of the cetacean community in summer months east of Great Abaco, Bahamas. *Journal of the Marine Biological Association of the United Kingdom* 84: 469-474.

MacLeod, C. D., N. Hauser, and H. Peckham (2006). Known and inferred distributions of beaked whale species (Ziphiidae: Cetacea). *Journal of Cetacean Research and Management* 7(3): 271-286.

MacLeod, C. D., and G. Mitchell (2006). Key areas for beaked whales worldwide. *Journal of Cetacean Research and Management* 7(3): 309-322.

MacLeod, C.D., M. P. Simmonds, and E. Murry (2006). Abundance of fin (*Balaenoptera physalus*) and sei whales (B. *borealis*) amid oil exploration and development off northwest Scotland. Journal of Cetacean Research and Management (3) Vol. 8, pp. 247-254.

Madsen, P. T., D. A. Carder, K. Bedholm and S. H. Ridgway (2005). Porpoise clicks from a sperm whale nose – convergent evolution of 130 kHz pulses in toothed whale sonars? *Bioacoustics* 15: 195–206.

Maldini Feinholz, D. (2003). Abundance and Distribution Patterns of Hawaiian Odontocetes: Focus on O'ahu. Ph.D. dissertation, University of Hawaii.

Maldini, D., L. Mazzuca, and S. Atkinson (2005). Odontocete stranding patterns in the main Hawaiian Islands (1937-2002): How do they compare with live animal surveys? *Pacific Science* 59(1): 55-67.

Marcoux, M., H. Whitehead, and L. Rendell (2007). Sperm whale feeding variations by location, year, social group and clan: Evidence from stable isotopes. *Marine Ecology Progress Series* 333: 309-314.

Marine Mammal Commission (2002). *Hawaiian Monk Seal (*Monachus schauinslandi*).* Species of Special Concern, Annual Report to Congress, 2001. Bethesda, MD, Marine Mammal Commission**:** 63-76.

Marine Mammal Commission (2003). Workshop on the Management of Hawaiian Monk Seals on Beaches in the Main Hawaiian Islands: 5.

Marini, L., C. Consiglio, B. Catalano, and T. Valentini (1996). Aerial behavior in fin whales (*Balaenoptera physalus*) in the Mediterranean Sea. *Marine Mammal Science* 12(3):489-495. July.

Marsh, H. E. (1989). Mass Stranding of Dugongs by a Tropical Cyclone in Northern Australia. *Marine Mammal Science* 5(1): 78-84.

Marten, K. (2000). Ultrasonic analysis of pygmy sperm whale (*Kogia breviceps*) and Hubbs' beaked whale (*Mesoplodon carlhubbsi*) clicks. *Aquatic Mammals* 26(1): 45-48.

Marten, K., and S. Psarakos (1999). Long-term site fidelity and possible long-term associations of wild spinner dolphins (*Stenella longirostris*) seen off Oahu, Hawaii. *Marine Mammal Science* 15(4): 1329-1336.

Martin, S. W., C. R. Martin, B. M. Matsuyama, and E. E. Henderson (2015). Minke whales (*Balaenoptera acutorostrata*) respond to Navy training. *Journal of the Acoustical Society of America* 137(5), May 2015.

Martin, C. R., S. W. Martin, E. E. Henderson, T. A. Helble, R. A. Manzano-Roth, and B. M. Matsuyama (2016). *SSC Pacific FY15 Annual Report on PMRF Marine Mammal Monitoring.*

Masaki, Y. (1976). Biological studies on the North Pacific sei whale. *Bulletin of the Far Seas Fisheries Research Laboratory* 14: 1-104.

Masaki, Y. (1977). The separation of the stock units of sei whales in the North Pacific. *Reports of the International Whaling Commission (Special Issue 1)*: 71-79.

Mate, B. R., R. Gisiner, and J. Mobeley (1998). Local and migratory movements of Hawaiian humpback whales tracked by satellite telemetry. *Canadian Journal of Zoology*, Vol 76.

Matkin, C. O., E. L. Saulitis, G. M. Ellis, P. Olesiuk, S. D. Rice (2008). Ongoing population-level impacts on killer whales Orcinus orca following the 'Exxon Valdez' oil spill in Prince William Sound, Alaska. *Marine Ecology Progress Series*, 356, 269-281. doi: 10.3354/meps07273.

McAlpine, D. F. (2009). Pygmy and dwarf sperm whales *Kogia breviceps* and ***K. sima.*** In *Encyclopedia of Marine Mammals* (Second Edition). W. F. Perrin, B. Wursig and J. G. M. Thewissen, Academic Press**:** 936-938.

McCracken, M. L., and K. A. Forney (2010). *Preliminary Assessment of Incidental Interactions with Marine Mammals in the Hawaii Longline Deep and Shallow Set Fisheries*. National Marine Fisheries Service, PIFSC Working Paper WP-10-001.

McDonald, M., J. Hildebrand, S. Wiggins, and D. Ross (2008). A 50 year comparison of ambient ocean noise near San Clemente Island: A bathymetrically complex coastal region off Southern California. *Journal of the Acoustical Society of America*: 1985-1992.

McSweeney, D. J., R. W. Baird, and S. D. Mahaffy (2007). Site fidelity, associations, and movements of Cuvier's (*Ziphius cavirostris*) and Blainville's (*Mesoplodon densirostris*) beaked whales off the Island of Hawaii. *Marine Mammal Science* 23(3): 666-687.

Mead, J. G. (1989). Beaked whales of the genus *Mesoplodon.* In *Handbook of Marine Mammals*. S. H. Ridgway and R. Harrison. San Diego, CA, Academic Press. 4: 349-430.

Mead, J. G., and C. W. Potter (1995). Recognizing two populations of the bottlenose dolphin (*Tursiops truncatus*) off the Atlantic Coast of North America: Morphologic and ecologic considerations. *IBI Reports* 5: 31-44.

Mignucci-Giannoni, A. A. (1998). Zoogeography of cetaceans off Puerto Rico and the Virgin Islands. *Caribbean Journal of Science* 34(3-4): 173-190.

Miyashita, T. (1993). Distribution and abundance of some dolphins taken in the North Pacific driftnet fisheries. *International North Pacific Fisheries Commission Bulletin* 53(3): 435-450.

Miyashita, T., T. Kishiro, N. Higashi, F. Sato, K. Mori, and H. Kato (1996). Winter distribution of cetaceans in the western North Pacific inferred from sighting cruises 1993-1995. Reports of the International Whaling Commission 46: 437-442.

Miyazaki, N., and W. F. Perrin (1994). Rough-toothed dolphin *Steno bredanensis* (Lesson, 1828). In *Handbook of Marine Mammals*. S. H. Ridgway and R. Harrison. San Diego, CA, Academic Press. 5: 1-21.

Miyazaki, N., and S. Wada (1978). Fraser's dolphin, *Lagenodelphis hosei* in the western North Pacific. Scientific Reports of the Whales Research Institute 30: 231-244.

Mizroch, S. A., D. W. Rice, D. Zwiefelhofer, J. Waite, and W. L. Perryman (2009). Distribution and movements of fin whales in the North Pacific Ocean. Mammal Review 39: 193-227.

Mobley, J. R. (2004). *Results of Marine Mammal Surveys on U.S. Navy Underwater Ranges in Hawaii and Bahamas***:** 27.

Mobley, J. R. (2005). Assessing responses of humpback whales to North Pacific Acoustic Laboratory (NPAL) transmissions: Results of 2001-2003 aerial surveys north of Kauai. *Journal of the Acoustical Society of America* 117: 1666-1773.

Mobley, J. R., Jr., G. B. Bauer, and L. M. Herman (1999). Changes over a ten-year interval in the distribution and relative abundance of humpback whales (*Megaptera novaeangliae*) wintering in Hawaiian waters. *Aquatic Mammals* 25: 63-72.

Mobley, J. R., Jr., L. Mazzuca, A. S. Craig, M. W. Newcomer, and S. S. Spitz (2001). Killer whales (*Orcinus orca*) sighted west of Ni'ihau, Hawai'i. *Pacific Science* 55: 301-303.

Mobley, J. R., Jr., M. Smultea, T. Norris, and D. Weller (1996). Fin whale sighting north of Kaua'i, Hawai'i. *Pacific Science* 50: 230-233.

Mobley, J. R., Jr., S. S. Spitz, K. A. Forney, R. Grotefendt, and P. H. Forestell (2000). *Distribution and Abundance of Odontocete Species in Hawaiian Waters: Preliminary Results of 1993-98 Aerial Surveys*, Southwest Fisheries Science Center**:** 26.

Mobley, J. Jr., S. Spitz, and R. Grotefendt (2001). *Abundance of Humpback Whales in Hawaiian Waters: Results of 1993-2000 Aerial Surveys.* Prepared for the Hawaiian Islands Humpback Whale National Marine Sanctuary and Department of Land and Natural Resources, State of Hawaii. September 2001.

Møhl, B. (1968). Auditory sensitivity of the common seal in air and water. *Journal of Auditory Research* 8: 27-38.

Moon, H. B., K. Kannan, M. Choi, J. Yu, H. G. Choi, Y. R. An, and Z. G. Kim (2010). Chlorinated and brominated contaminants including PCBs and PBDEs in minke whales and common dolphins from Korean coastal waters. *Journal of Hazardous Materials*, 179(1-3), 735-741.

Moore, J. C. (1972). More skull characters of the beaked whale *Indopacetus pacificus* and comparative measurements of austral relatives. *Fieldiana Zoology* 62: 1-19.

Moretti, D., T.A. Marques, L. Thomas, N. DiMarzio, A. Dilley, R. Morrissey, E. McCarthy, J. Ward, and S. Jarvis (2010). A dive counting density estimation method for Blainville's beaked whale (Mesoplodon densirostris) using a bottom-mounted hydrophone field as applied to a Mid-Frequency Active (MFA) sonar operation. *Applied Acoustics* 71:1036-1042.

Mussi, B., A. Miragliuolo, T. De Pippo, M. C. Gambi, and D. Chiota (2004). The submarine canyon of Cuma (southern Tyrrhenian Sea, Italy), a cetacean key area to protect. *European Research on Cetaceans* 15: 178-179.

Nachtigall, P. E., T. A. Mooney, K. A. Taylor, L. A. Miller, M. H. Rasmussen, T. Akamatsu, J. Teilmann, M. Linnenschmidt, and G. A. Vikingsson (2008). Shipboard measurements of the hearing of the white-beaked dolphin *Lagenorhynchus albirostris*. *Journal of Experimental Biology* 211: 642-647.

Nachtigall, P. E., M. M. L. Yuen, T. A. Mooney, and K. A. Taylor (2005). Hearing measurements from a stranded infant Risso's dolphin, *Grampus griseus*. *Journal of Experimental Biology* 208: 4181-4188.

National Marine Fisheries Service (1986). Designated critical habitat; Hawaiian monk seal. Federal Register 51(83): 16047-16053.

National Marine Fisheries Service (1988). Critical habitat; Hawaiian monk seal; Endangered Species Act. Federal Register 53(102): 18988-18998.

National Marine Fisheries Service (2007a). Pacific Islands Region, Marine Mammal Response Network Activity Update #5.

National Marine Fisheries Service (2007b). Recovery plan for the Hawaiian monk seal (*Monachus schauinslandi*). Silver Spring, MD, National Marine Fisheries Service**:** 165.

National Marine Fisheries Service (2008). Pacific Islands Region, Marine Mammal Response Network Activity Update #8.

National Marine Fisheries Service (2009). Taking and Importing of Marine Mammals; U.S. Navy Training in the Hawaii Range Complex; Final Rule. Federal Register, Monday, January 12, 2009, 74(7):1456-1491.

National Marine Fisheries Service (2010a). Pacific Islands Region, Marine Mammal Response Network Activity Update #14 (pp. 6).

National Marine Fisheries Service (2010b). Pacific Islands Regional Office. Hawaiian monk seal top threats. 2010.

National Marine Fisheries Service (2010c). Pacific Islands Regional Office. Hawaiian monk seal population and location. 2010.

National Marine Fisheries Service (2011a). Pacific Islands Region, Marine Mammal Response Network Activity Update #17.

National Marine Fisheries Service (2011b). Pacific Science Center Stranding Data. Excel file containing stranding from the Hawaiian Islands, manuscript on file.

National Marine Fisheries Service (2012). Endangered and Threatened Wildlife and Plants; Endangered Status for the Main Hawaiian Islands Insular False Killer Whale Distinct Population Segment. Federal Register, 77(229), 70915-70939.

National Marine Fisheries Service (2014). *Final Programmatic Environmental Impact Statement for Hawaiian Monk Seal Recovery Actions*. March 2014.

National Marine Fisheries Service (2016). *Species in the Spotlight. Priority Actions: 2016-2020. Hawaiian Monk Seal 5-Year Action Plan*.

National Oceanic and Atmospheric Administration (NOAA) (2010). *Hawaiian Islands Humpback Whale National marine sanctuary Condition Report 2010*. August 2010.

National Oceanic and Atmospheric Administration (NOAA) (2012). Endangered and Threatened Wildlife and Plants; Endangered Status for the Main Hawaiian Islands Insular False Killer Whale Distinct Population Segment. Federal Register, 77(229), 70915-70939.

National Oceanographic and Atmospheric Administration (NOAA) (2014). NOAA Fisheries Protected Resources. Accessed from http://www.nmfs.noaa.gov/pr/species/mammals/cetaceans/minkewhale.htm. Last updated on June 26, 2014. Accessed on February 18, 2016.

National Oceanographic and Atmospheric Administration (NOAA) (2015). *Draft Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing: Underwater Acoustic Threshold Levels for Onset of Permanent and Temporary Threshold Shifts*. Revised Version for Second Public Comment Period. July 23, 2015.

National Oceanic and Atmospheric Administration (NOAA) Fisheries (2015). Hawaiian Monk Seal (*Neomonachus schauinslandi*). NOAA Pacific Islands Fisheries Science Center. Information last updated on August 21, 2015, and accessed at http://www.fisheries.noaa.gov/pr/species/mammals/seals/hawaiian-monk-seal.html. Information accessed on January 26, 2016.

National Research Council (2003). Ocean Noise and Marine Mammals (pp. 219). Washington, DC: National Academies Press.

National Research Council (2005). Marine Mammal Populations and Ocean Noise. Washington, DC: National Academies Press.

Natoli, A., V. M. Peddemors, and A. R. Hoelzel (2004). Population structure and speciation in the genus Tursiops based on microsatellite and mitochondrial DNA analyses. *Journal of Evolutionary Biology* 17: 363-375.

Nemoto, T., and A. Kawamura (1977). Characteristics of food habits and distribution of baleen whales with special reference to the abundance of North Pacific sei and Bryde's whales. *Reports of the International Whaling Commission* Special Issue 1: 80-87.

Norman, S. A., C. E. Bowlby, M. S. Brancato, J. Calambokidis, D. Duffield, P. J. Gearin, T. A. Gornall, M. E. Gosho, B. Hanson, J. Hodder, S. J. Jeffries, B. Lagerquist, D. M. Lambourn, B. Mate, B. Norberg, R. W. Osborne, J. A. Rash, S. Riemer, and J. Scordino (2004). Cetacean strandings in Oregon and Washington between 1930 and 2002. *Journal of Cetacean Research and Management* 6(1): 87-99.

Norris, K. S., and T. P. Dohl (1980). Behavior of the Hawaiian spinner dolphin, *Stenella longirostris*. *Fishery Bulletin* 77: 821-849.

Norris, T. F., M. McDonald, and J. Barlow (1999). Acoustic detections of singing humpback whales (*Megaptera novaeangliae*) in the eastern North Pacific during their northbound migration. *Journal of the Acoustical Society of America* 106(1): 506-514.

Norris, T. F., M. A. Smultea, A. M. Zoidis, S. Rankin, C. Loftus, C. Oedekoven, J. L. Hayes, and E. Silva (2005). *A Preliminary Acoustic-Visual Survey of Cetaceans in Deep Waters around Ni'ihau, Kaua'i, and portions of O'ahu, Hawai'i from Aboard the R/V* Dariabar. Bar Harbor, ME**:** 75.

Norris, K. S., B. Wursig, R. S. Wells, and M. Wursig (1994). *The Hawaiian Spinner Dolphin*. Berkeley, CA, University of California Press**:** 408.

Northridge, S. (2008). Fishing industry, effects of. In *Encyclopedia of Marine Mammals*. W. F. Perrin, B. Wursig and J. G. M. Thewissen. San Diego, CA, Academic Press: 443-447.

Nowacek, D., L. H. Thorne, D. Johnston, and P. Tyack (2007). Responses of cetaceans to anthropogenic noise. *Mammal Review* 37(2): 81-115.

Odell, D. K., and K. M. McClune (1999). False killer whale -- *Pseudorca crassidens* (Owen, 1846). In *Handbook of Marine Mammals*. S. H. Ridgway and S. R. Harrison. New York, Academic Press. 6: The second book of dolphins and the porpoises: 213-244.

Ohizumi, H., and T. Kishiro (2003). Stomach contents of a Cuvier's beaked whale (*Ziphius cavirostris*) stranded on the central Pacific coast of Japan. *Aquatic Mammals* 29(1): 99-103.

Ohizumi, H., T. Matsuishi, and H. Kishino (2002). Winter sightings of humpback and Bryde's whales in tropical waters of the western and central North Pacific. *Aquatic Mammals* 28(1): 73-77.

Okamura, H., A. Yatsu, T. Miyashita, and S. Kawahara (2001). The development of the ecosystem model for the western North Pacific area off Japan, Paper SC/53/O9 presented to the IWC Scientific Committee, July, Hammersmith (unpublished), 36pp.

Oleson, E. M, R. W. Baird, K. K. Martien, and B. L. Taylor (2013). *Island-associated stocks of odontocetes in the main Hawaiian Islands: A synthesis of available information to facilitate evaluation of stock structure*. Pacific Islands Fisheries Science Center Working Paper WP-13-003.

Oleson, E. M., C. H. Boggs, K. A. Forney, B. Hanson, D. R. Kobayashi, B. L. Taylor, P. Wade, and G. M. Ylitalo (2010). *Status Review of Hawaiian Insular False Killer Whales (*Pseudorca crassidens*) under the Endangered Species Act*, U.S. Department of Commerce and National Oceanic and Atmospheric Administration**:** 140 + Appendices.

Oleson, E., and M. Hill (2009). *Report to PACFLT: Data Collection and Preliminary Results from the Main Hawaiian Islands Cetacean Assessment Survey & Cetacean Monitoring Associated with Explosives Training off Oahu. 2010 Annual Range Complex Monitoring Report for Hawaii and Southern California.*

Olson, P. A. (2009). Pilot whales *Globicephala melas* and *G. macrorhynchus*. In *Encyclopedia of Marine Mammals*. W. F. Perrin, B. Würsig and J. G. M. Thewissen. San Diego, CA, Academic Press**:** 898-903.

Östman-Lind, J., A. D. Driscoll-Lind, and S. H. Rickards (2004). *Delphinid Abundance, Distribution and Habitat Use off the Western Coast of the Island of Hawaii*. La Jolla, CA, National Marine Fisheries Service.

Oswald, J. N., J. Barlow, and T. F. Norris (2003). Acoustic identification of nine delphinid species in the eastern tropical Pacific Ocean. *Marine Mammal Science* 19(1): 20-37.

Pacini, A. F., P. E. Nachtigall, C. T. Quintos, T. D. Schofield, D. A. Look, G. A. Levine, and J. P. Turner (2011). Audiogram of a stranded Blainville's beaked whale (*Mesoplodon densirostris*) measured during auditory evoked potentials. *Journal of Experimental Biology* 214: 2409-2415.

Panigada, S., M. Zanardelli, M. Mackenzie, C. Donovan, F. Melin, and P. Hammond (2008). Modelling habitat preferences for fin whales and striped dolphins in the Pelagos Sanctuary (Western Mediterranean Sea) with physiographic and remote sensing variables. *Remote Sensing of Environment* 112(8): 3400-3412.

Paniz-Mondolfi, A. E., and L. Sander-Hoffmann (2009). Lobomycosis in inshore and estuarine dolphins. *Emerging Infectious Diseases* 15(4): 672-673.

Parrish, F. A., G. J. Marshall, B. Buhleier, and G. A. Antonelis (2008). Foraging interaction between monk seals and large predatory fish in the Northwestern Hawaiian Islands. *Endangered Species Research* 4(3): 299-308.

Parrish, F. A., M. P. Craig, T. J. Ragen, G. J. Marshall, and B. M. Buhleier (2000). Identifying diurnal foraging habitat of endangered Hawaiian monk seals using a seal-mounted video camera. *Marine Mammal Science* 16(2): 392-412.

Payne, P. M., and D. W. Heinemann (1993). The distribution of pilot whales (*Globicephala* spp.) in shelf/shelf edge and slope waters of the northeastern United States, 1978-1988. *Reports of the International Whaling Commission* Special Issue 14: 51-68.

Perkins, J. S. and G. W. Miller (1983). Mass stranding of *Steno bredanensis* in Belize. *Biotropica* 15(3): 235-236.

Perrin, W. F. (1976). First record of the melon-headed whale, *Peponocephala electra*, in the eastern Pacific, with a summary of world distribution. *Fishery Bulletin* 74(2): 457-458.

Perrin, W. F. (2001). *Stenella attenuata*. *Mammalian Species* 683: 1-8.

Perrin, W. F. (2008b). Pantropical spotted dolphin *Stenella attenuata*. In *Encyclopedia of Marine Mammals*. W. F. Perrin, B. Wursig and J. G. M. Thewissen, Academic Press: 819-821.

Perrin, W. F. (2008c). Spinner dolphin *Stenella longirostris*. In *Encyclopedia of Marine Mammals*. W. F. Perrin, B. Wursig and J. G. M. Thewissen, Academic Press: 1100-1103.

Perrin, W. F., P. B. Best, W. H. Dawbin, K. C. Balcomb, R. Gambell, and G. J. B. Ross (1973). Rediscovery of Fraser's dolphin *Lagenodelphis hosei*. *Nature* 241: 345-350.

Perrin, W. F., and J. W. Gilpatrick, Jr. (1994). Spinner dolphin *Stenella longirostris* (Gray, 1828). In *Handbook of Marine Mammals, Volume 5: The first book of dolphins*. S. H. Ridgway and R. Harrison. San Diego, CA, Academic Press. 5: 99-128.

Perrin, W. F., and A. A. Hohn (1994). Pantropical spotted dolphin *Stenella attenuata*. In *Handbook of Marine Mammals.* S. H. Ridgway and R. Harrison. San Diego, CA, Academic Press. 5: 71-98.

Perrin, W. F., S. Leatherwood, and A. Collet (1994b). Fraser's dolphin *Lagenodelphis hosei* Fraser, 1956. In *Handbook of Marine Mammals, Volume 5: The first book of dolphins*. S. H. Ridgway and R. Harrison. San Diego, California, Academic Press: 225-240.

Perrin, W. F., C. E. Wilson, and F. I. Archer II (1994a). Striped dolphin--*Stenella coeruleoalba* (Meyen, 1833). In *Handbook of Marine Mammals*. S. H. Ridgway and R. Harrison. San Diego, CA, Academic Press. 5: The First Book of Dolphins: 129-159.

Perrin, W. F., B. Würsig, and J. G. M. Thewissen (2009). *Encyclopedia of Marine Mammals*. Second Edition. Academic Press, Amsterdam.

Perry, S. L., D. P. DeMaster, and G. K. Silber (1999). The great whales: history and status of six species listed as Endangered under the U.S. Endangered Species Act of 1973. *Marine Fisheries Review* 61(1): 1-74.

Perryman, W. L. (2008). Melon-headed whale *Peponocephala electra*. In *Encyclopedia of Marine Mammals*. W. F. Perrin, B. Wursig and J. G. M. Thewissen, Academic Press**:** 719-721.

Perryman, W. L., D. W. K. Au, S. Leatherwood, and T. A. Jefferson (1994). Melon-headed whale *Peponocephala electra* Gray, 1846. *Handbook of Marine Mammals, Volume 5: The first book of dolphins*. S. H. Ridgway and R. Harrison, Academic Press**:** 363-386.

Perryman, W. L., and T. C. Foster (1980). *Preliminary Report on Predation by Small Whales, Mainly the False Killer Whale,* Pseudorca crassidens*, on Dolphins (*Stenella spp*. and* Delphinus delphis*) in the Eastern Tropical Pacific*. La Jolla, CA, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center**:** 9.

Pierce, G., M. Santos, C. Smeenk, A. Saveliev, and A. Zuur (2007). Historical trends in the incidence of strandings of sperm whales (*Physeter macrocephalus*) on North Sea coasts: An association with positive temperature anomalies. *Fisheries Research* 87(2-3): 219-228.

Pitman, R. (2008). Indo-Pacific beaked whale *Indopacetus pacificus*. In *Encyclopedia of Marine Mammals*. W. F. Perrin, B. Wursig and J. G. M. Thewissen, Academic Press**:** 600-602.

Pitman, R. L., D. W. K. Au, M. D. Scott, and J. M. Cotton (1988). *Observations of Beaked Whales (*Ziphiidae*) from the Eastern Tropical Pacific Ocean*, International Whaling Commission.

Pitman, R. L., H. Fearnbach, R. LeDuc, J. W. Gilpatrick, Jr., J. K. B. Ford, and L. T. Ballance (2007). Killer whales preying on a blue whale calf on the Costa Rica Dome: Genetics, morphometrics, vocalisations and composition of the group. *Journal of Cetacean Research and Management* 9(2): 151-157.

Pitman, R. L., and C. Stinchcomb (2002). Rough-toothed dolphins (*Steno bredanensis*) as predators of mahi mahi (*Coryphaena hippurus*). *Pacific Science* 56(4): 447-450.

Poole, M. M. (1995). Aspects of the behavioral ecology of spinner dolphins (*Stenella longirostris*) in the nearshore waters of Mo'orea, French Polynesia. Ph.D. dissertation, University of California, Santa Cruz.

Popov, V. V., A. Y. Supin, M. G. Pletenko, V. O. Klishin, Bulgakova, T.N., and E. I. Rosanova (2007). Audiogram variability in normal bottlenose dolphins (*Tursiops truncatus*). *Aquatic Mammals* 33:24-33.

Pryor, T., K. Pryor, and K. S. Norris (1965). Observations on a pygmy killer whale (*Feresa attenuata* Gray) from Hawaii. *Journal of Mammalogy* 46(3): 450-461.

Rankin, S., and J. Barlow (2005). Source of the North Pacific “boing” sound attributed to minke whales. *Journal of the Acoustical Society of America* 118: 3346-3351.

Rankin, S., and J. Barlow (2007). Sounds recorded in the presence of Blainville's beaked whales, *Mesoplodon densirostris*, near Hawaii (L). *Journal of the Acoustical Society of America* 122(1): 42-45.

Rankin, S., T. F. Norris, M. A. Smultea, C. Oedekoven, A. M. Zoidis, E. Silva, and J. Rivers (2007). A visual sighting and acoustic detections of minke whales, *Balaenoptera acutorostrata* (Cetacea: Balaenopteridae), in nearshore Hawaiian waters. *Pacific Science* 61: 395-398.

Read, A. J. (2008). The looming crisis: Interactions between marine mammals and fisheries. *Journal of Mammalogy* 89(3): 541-548.

Reeves, R., S. Leatherwood, and R. Baird (2009). Evidence of a possible decline since 1989 in false killer whales (*Pseudorca crassidens*) around the main Hawaiian Islands. *Pacific Science* 63: 253-261.

Reeves, R. R., W. F. Perrin, B. L. Taylor, C. S. Baker and S. L. Mesnick (2004). *Report of the Workshop on Shortcomings of Cetacean Taxonomy in Relation to Needs of Conservation and Management, April 30 - May 2, 2004 La Jolla, California*. La Jolla, CA, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center**:** 94.

Reeves, R. R., B. S. Stewart, P. J. Clapham, and J. A. Powell (2002). *National Audubon Society Guide to Marine Mammals of the World*. New York, NY, Alfred A. Knopf**:** 527.

Reichmuth, C. (2008). Hearing in marine carnivores. *Bioacoustics* 17: 89-92.

Reilly, S. B. (1990). Seasonal changes in distribution and habitat differences among dolphins in the eastern tropical Pacific. *Marine Ecology Progress Series* 66: 1-11.

Reilly, S. B., J. L. Bannister, P. B. Best, M. Brown, R. L. Brownell Jr., D. S. Butterworth, P. J. Clapham, J. Cooke, G. P. Donovan, J. Urbán, and A. N. Zerbini (2008). *Eubalaena japonica*. In *IUCN 2012. IUCN Red List of Threatened Species*. Version 2012.1. <www.iucnredlist.org>. Downloaded on 29 September 2012.

Reuland, K. (2010). *Habitat Use and Behavioral Monitoring of Hawaiian Monk Seals in Proximity to the Navy Hawaii Range Complex*. Annual Range Complex Monitoring Report for Hawaii and Southern California.

Rice, D. W. (1998). Marine mammals of the world: systematics and distribution. *Society for Marine Mammalogy* Special Publication. Lawrence, KS, Society for Marine Mammalogy: 231.

Rice, D. W. (1989). Sperm whale *Physeter macrocephalus* Linnaeus, 1758. In *Handbook of Marine Mammals, Volume 4: River dolphins and the larger toothed whales*. S. H. Ridgway and R. Harrison. San Diego, CA, Academic Press. 4: 177-234.

Richardson, W. J., C. R. J. Green, C. I. Malme, and D.H. Thomson (1995). *Marine Mammals and Noise*. San Diego, CA, Academic Press.

Richmond, D. R., J. T. Yelverton, and E. R. Fletcher (1973). Far-Field Underwater-Blast Injuries Produced by Small Charges. Washington, DC, Lovelace Foundation for Medical Education and Research, Defense Nuclear Agency: 108.

Ridgway, S. H., and D. A. Carder (2001). Assessing hearing and sound production in cetaceans not available for behavioral audiograms: Experiences with sperm, pygmy sperm, and gray whales. *Aquatic Mammals* 27(3): 267-276.

Ridgway, S. H., and M. D. Dailey (1972). Cerebral and cerebellar involvement of trematode parasites in dolphins and their possible role in stranding. *Journal of Wildlife Diseases* 8(1):33-43.

Ridgway, S. H., R. J. Harrison, and P. L. Joyce (1975). Sleep and cardiac rhythm in the gray seal. *Science* 187: 553-554.

Ritter, F. (2002). Behavioural observations of rough-toothed dolphins (*Steno bredanensis*) off La Gomera, Canary Islands (1995-2000), with special reference to their interactions with humans. *Aquatic Mammals* 28(1): 46-59.

Robertson, K. M., and S. J. Chivers (1997). Prey occurrence in pantropical spotted dolphins, *Stenella attenuata*, from the eastern tropical Pacific. *Fishery Bulletin* 95(2): 334-348.

Rolland, R.M., Susan E. Parks, Kathleen E. Hunt, Manuel Castellote, Peter J. Corkeron, Douglas P. Nowacek, Samuel K. Wasser, and Scott D. Kraus (2012). Evidence that ship noise increases stress in right whales. *Proc. R. Soc. B Biological Sciences* 279, 2363-2368. doi: 10.1098/rspb.2011.2429.

Rosel, P. E., and H. Watts (2008). Hurricane impacts on bottlenose dolphins in the northern Gulf of Mexico. *Gulf of Mexico Science* 25(1): 88-94.

Ross, G. J. B. (1971). Shark attack on an ailing dolphin *Stenella coeruleoalba* (Meyen). *South African Journal of Science* 67: 413-414.

Ross, G. J. B., and S. Leatherwood (1994). Pygmy killer whale *Feresa attenuata* Gray, 1874. *Handbook of Marine Mammals, Volume 5: The first book of dolphins*. S. H. Ridgway and R. Harrison, Academic Press**:** 387-404.

Rowntree, V., J. Darling, G. Silber, and M. Ferrari (1980). Rare sighting of a right whale (*Eubalaena glacialis*) in Hawaii. *Canadian Journal of Zoology* 58: 4.

Salden, D. R. (1989). An observation of apparent feeding by a sub-adult humpback whale off Maui, Hawaii. [Abstract]. Presented at the Eighth Biennial Conference on the Biology of Marine Mammals, Pacific Grove, CA. 7-11 December.

Salden, D. R., L. M. Herman, M. Yamaguchi, and F. Sato (1999) Multiple visits of individual humpback whales (*Megaptera novaeangliae*) between the Hawaiian and Japanese winter grounds. *Canadian Journal of Zoology* 77: 504-508.

Salden, D., and J. Mickelsen (1999). Rare sighting of a north pacific right whale (*Eubalaena glacialis*) in Hawai'i. *Pacific Science*, 53(4), 341-345.

Santos, M. B., V. Martin, et al. (2007). Insights into the diet of beaked whales from the atypical mass strandings in the Canary Islands in September 2002. *Journal of the Marine Biological Association of the United Kingdom* 87: 243-251.

Schilling, M. R., I. Seipt, M. T. Weinrich, S. E. Frohock, A. E. Kuhlberg, and P. J. Clapham (1992). Behavior of individually identified sei whales *Balaenoptera borealis* during an episodic influx into the southern Gulf of Maine in 1986. *Fishery Bulletin* 90: 749-755.

Schlundt, C. E., J. J. Finneran, D. A. Carder, and S. H. Ridgway (2000). Temporary shift in masked hearing thresholds of bottlenose dolphins, *Tursiops truncatus*, and white whales, *Delphinapterus leucas*, after exposure to intense tones. *Journal of the Acoustical Society of America*, 107(6), 3496-3508.

Schmelzer, I. (2000). Seals and seascapes: Covariation in Hawaiian monk seal subpopulations and the oceanic landscape of the Hawaiian Archipelago. *Journal of Biogeography* 27: 901-914.

Scott, M. D., and S. J. Chivers (1990). Distribution and herd structure of bottlenose dolphins in the eastern tropical Pacific Ocean. In *The Bottlenose Dolphin*. S. Leatherwood and R. R. Reeves, Academic Press**:** 387-402.

Scott, Michael, and Susan Chivers (2009). Movements and Diving Behavior of Pelagic Spotted Dolphins. Publications, Agencies and Staff of the U.S. Department of Commerce. Paper 46.

Sears, R., and W. F. Perrin (2008). Blue whale. In *Encyclopedia of Marine Mammals*. W. F. Perrin, B. Wursig and J. G. M. Thewissen. San Diego, CA, Academic Press: 120-124.

Sekiguchi, K., N. T. W. Klages, and P. B. Best (1992). Comparative analysis of the diets of smaller odontocete cetaceans along the coast of southern Africa. *South African Journal of Marine Science* 12: 843-861.

Shallenberger, E. W. (1981). *The Status of Hawaiian Cetaceans*. Kailua, HI, Manta Corporation: 79.

Shane, S. H. (1990). Comparison of bottlenose dolphin behavior in Texas and Florida, with a critique of methods for studying dolphin behavior. In *The Bottlenose Dolphin*. S. Leatherwood and R. R. Reeves. San Diego, CA, Academic Press**:** 541-558.

Širović, A., J. A. Hildebrand, S. M. Wiggins, M. A. McDonald, S. E. Moore, and D. Thiele (2004). Seasonality of blue and fin whale calls and the influence of sea ice in the Western Antarctic Peninsula. *Deep-Sea Research II*. 51:2327-2344.

Smith, B. D., G. Braulik, S. Strindberg, R. Mansur, M. A. A. Diyan, and B. Ahmed (2009). Habitat selection of freshwater-dependent cetaceans and the potential effects of declining freshwater flows and sea level rise in waterways of the Sundarbans mangrove forest, Bangladesh. *Aquatic Conservation: Marine and Freshwater Ecosystems* 19: 209-225.

Smultea, M. A. (1994). Segregation by humpback whale (*Megaptera novaeangliae*) cows with a calf in coastal habitat near the island of Hawaii. *Canadian Journal of Zoology* 72: 805-811.

Smultea, M. A., J. L. Hopkins, and A. M. Zoidis (2008). *Marine Mammal and Sea Turtle Monitoring Survey in Support of Navy Training Exercises in the Hawai'i Range Complex November 11-17, 2007*. C. R. Organization. Oakland, CA: 62.

Smultea, M. A., J. L. Hopkins, and A. M. Zoidis (2007). *Marine Mammal Visual Survey in and near the Alenuihaha Channel and the Island of Hawai'i: Monitoring in Support of Navy Training Exercises in the Hawai'i Range Complex, January 27 – February 2, 2007*. Oakland, CA**:** 63.

Smultea, M. A., T. A. Jefferson, and A. M. Zoidis (2010). Rare sightings of a Bryde's whale (*Balaenoptera edeni*) and sei whales (*B. borealis*) (Cetacea: Balaenopteridae) northeast of O'ahu, Hawai'i. *Pacific Science* 64: 449-457.

Southall, B. L., A. E. Bowles, W. T. Ellison, J. J. Finneran, R. L. Gentry, C. R. Greene Jr., and P. L. Tyack (2007). Marine mammal noise and exposure criteria: initial scientific recommendations. *Aquatic Mammals, 33*, 411-521.

Southall, B., J. Calambokidis, P. Tyack, D. Moretti, J. Hildebrand, C. Kyburg, R. Carlson, A. S. Friedlaender, E. A. Falcone, G. S. Schorr, A. Douglas, S. L. Deruiter, J. A. Goldbogen, and J. Barlow (2011). *Biological and Behavioral Response Studies of Marine Mammals in Southern California, 2010 (“"SOCAL-10”) SOCAL-BRS* [Project Report]. (pp. 29).

Southall, B., J. Calambokidis, P. Tyack, D. Moretti, A. Friedlaender, S. DeRuiter, J. Goldbogen, E. Falcone, G. Schorr, A. Douglas, A. Stimpert, J. Hildebrand, C. Kyburg, R. Carlson, T. Yack, and J. Barlow (2012). *Biological and Behavioral Response Studies of Marine Mammals in Southern California, 2011 (“SOCAL-11”)*, Final Project Report, 8 March 2012. Manuscript on file.

Southall, B. L., P. L. Tyack, D. Moretti, C. Clark, D. Claridge, I. Boyd (2009). Behavioral responses of beaked whales and other cetaceans to controlled exposures of simulated sonar and other sounds, 18th Biennial Conference on the Biology of Marine Mammals. Quebec City, Quebec, Canada.

Stafford, K., D. Bohnenstiehl, M. Tolstoy, E. Chapp, D. Mellinger, and S. Moore (2004). Antarctic-type blue whale calls recorded at low latitudes in the Indian and eastern Pacific oceans. *Deep-Sea Research* I 51: 1337-1346.

Steiger, G., J. Calambokidis, J. Straley, L. Herman, S. Cerchio, D. Salden, J. Urban-R, J. Jacobsen, O. Ziegesar, K. Balcomb, C. Gabriele, M. Dahlheim, S. Uchida, J. Ford, P. Ladron de Guevara-P, M. Yamaguchi, and J. Barlow (2008). Geographic variation in killer whale attacks on humpback whales in the North Pacific: implications for predation pressure. *Endangered Species Research* 4(3): 247- 256.

Stewart, B. S., G. A. Antonelis, J. D. Baker, and P. K. Yochem (2006). Foraging biogeography of Hawaiian monk seals in the Northwestern Hawaiian Islands. *Atoll Research Bulletin* 543: 131–146.

Szymanski, M. D., D. E. Bain, K. Kiehl, S. Pennington, S. Wong, and K. R. Henry (1999). Killer whale (*Orcinus orca*) hearing: Auditory brainstem response and behavioral audiograms. *Journal of the Acoustical Society of America*, 106(2), 1134-1141.

Terhune, J. M. and K. Ronald (1971). The harp seal, *Pagophilus groenlandicus* (Erxleben, 1777) X. The air audiogram. *Canadian Journal of Zoology* 49: 385-390.

Terhune, J. M. and K. Ronald (1972). The harp seal, *Pagophilus groenlandicus* (Erxleben, 1777) III. The underwater audiogram. *Canadian Journal of Zoology* 50: 565-569.

Terhune, J. M., and K. Ronald (1975). Underwater hearing sensitivity of two ringed seals (*Pusa hispida*). *Canadian Journal of Zoology*, 53, 227-231.

Terhune, J. M., and K. Ronald (1976). The upper frequency limit of ringed seal hearing. *Canadian Journal of Zoology*, 54, 1226-1229.

Terhune, J., and S. Turnbull (1995). Variation in the psychometric functions and hearing thresholds of a harbour seal. In. Sensory Systems of Aquatic Mammals. R. A. Kastelein, J. A. Thomas and P. E. Nachtigall. Woerden, The Netherlands, De Spil Publishers: 81-93.

Thomas, J., P. Moore, R. Withrow, and M. Stoermer (1990). Underwater audiogram of a Hawaiian monk seal (*Monachus schauinslandi*). Journal of Acoustical Society of America 87(1): 417-420.

Thompson, P. M., D. Lusseau, T. Barton, D. Simmons, J. Rusin, and H. Bailey (2010). Assessing the responses of coastal cetaceans to the construction of offshore wind turbines. *Marine Pollution Bulletin* 60:1200-1208.

Twiss, J. R., Jr. and R. R. Reeves (1999). *Conservation and Management of Marine Mammals*. Washington, D.C., Smithsonian Institution Press**:** 471.

Tyack, P. L. (2009a). Human-generated sound and marine mammals. *Physics Today*: 39-44.

Tyack, P. L. (2009b). Acoustic playback experiments to study behavioral responses of free-ranging marine animals to anthropogenic sound. *Marine Ecology Progress Series*, 395, 13. 10.3354/meps08363

Tyack, P., W. Zimmer, D. Moretti, B. Southall, D. Claridge, J. Durban, and I. Boyd (2011). *Beaked Whales Respond to Simulated and Actual Navy Sonar*. [electronic version]. PLoS ONE, 6(3), 15. 10.1371/journal.pone.0017009.

Tyne, J., K. Pollock, D. Johnston, and L. Bejder (2013). *Abundance and survival rates of the Hawaii Island associated spinner dolphin (Stenella longirostris) stock*. PLoS ONE 9(1): e86132.

U.S. Department of the Navy (2001). "Appendix D: Physical impacts of explosions on marine mammals and turtles," in *Final Environmental Impact Statement: Shock Trial of the Winston S. Churchill (DDG 81)*, edited by J. James C. Craig (Department of the Navy and U.S. Department of Commerce, NOAA, National Marine Fisheries Service), pp. 1-43.

U.S. Department of the Navy (2006). *Rim of the Pacific Exercise After Action Report: Analysis of Effectiveness of Mitigation and Monitoring Measures as Required Under the Marine Mammals Protection Act (MMPA) Incidental Harassment Authorization and the National Defense Exemption from the Requirements of the MMPA for Mid-Frequency Active Sonar Mitigation Measures***:** 60.

U.S. Department of the Navy (2009). *Marine Species Monitoring for the U.S. Navy's Hawaii Range Complex and the Southern California Range Complex, 2009 Annual Report*. Available at www.nmfs.noaa.gov/pr/permits/incidental.htm#applications.

U.S. Department of the Navy (2011). *Marine Species Monitoring for the U.S. Navy's Hawaii Range Complex and the Southern California Range Complex, 2011 Annual Report*. Available at www.nmfs.noaa.gov/pr/permits/incidental.htm#applications.

U.S. Department of the Navy (2014). Commander Task Force 3rd and 7th Fleet Navy Marine Species Density Database. NAVFAC Pacific Technical Report. Naval Facilities Engineering Command Pacific, Pearl Harbor, HI.

U.S. Department of the Navy (2015). *Hawaii-Southern California Training and Testing (HSTT) - 2014 Annual Monitoring Report*. Prepared by Commander, U.S. Pacific Fleet, Pearl Harbor, Hawaii. Prepared for and submitted to National Marine Fisheries Service, Silver Spring, MD.

Van Waerebeek, K., F. Felix, B. Haase, D. Palacios, D. M. Mora-Pinto, and M. Munoz-Hincapie (1998). Inshore records of the striped dolphin, *Stenella coeruleoalba*, from the Pacific coast of South America. Reports of the International Whaling Commission 48: 525-532.

Verboom, W. C., and R. A. Kastelein (2003). Structure of harbour porpoise (*Phocoena phocoena*) acoustic signals with high repetition rates. J. A. Thomas, C. Moss and M. Vater (Eds.), *Echolocation in Bats and Dolphins* (pp. 40-43). University of Chicago Press.

Villadsgaard, A., M. Wahlberg, and J. Tougaard (2007). Echolocation signals of wild harbour porpoises, *Phocoena phocoena*. *Journal of Experimental Biology*, 2010, 56-64.

Wade, P. R. (1994). Abundance and Population Dynamics of Two Eastern Pacific Dolphins, *Stenella attenuata* and *Stenella longirostris orientalis*. (Doctoral dissertation). University of California, San Diego.

Wade, P. R., and T. Gerrodette (1993). Estimates of cetacean abundance and distribution in the eastern tropical Pacific. Reports of the International Whaling Commission 43: 477-493.

Wade, P. R., J. M. Ver Hoef, and D. P. DeMaster (2009). Mammal-eating killer whales and their prey — trend data for pinnipeds and sea otters in the North Pacific Ocean do not support the sequential megafaunal collapse hypothesis. *Marine Mammal Science* 25(3): 737-747.

Wang, J. Y., and S. C. Yang (2006). Unusual cetacean stranding events of Taiwan in 2004 and 2005. *Journal of Cetacean Research and Management* 8(3): 283-292.

Wang, J. Y., S. C. Yang, and H. C. Liao (2001). Species composition, distribution and relative abundance of cetaceans in the waters of southern Taiwan: Implications for conservation and eco-tourism. *Journal of the National Parks of Taiwan* 11(2): 136-158.

Waring, G. T., T. Hamazaki, D. Sheehan, G. Wood, and S. Baker (2001). Characterization of beaked whale (Ziphiidae) and sperm whale (*Physeter macrocephalus*) summer habitat in shelf-edge and deeper waters off the northeast U.S. *Marine Mammal Science* **17**(4): 703-717.

Watkins, W. A., M. A. Daher, G. M. Reppucci, J. E. George, D. L. Martin, N. A. DiMarzio, and D. P. Gannon (2000). Seasonality and distribution of whale calls in the North Pacific. *Oceanography* 13(1): 62-67.

Weller, D. W. (2008). Predation on marine mammals. In *Encyclopedia of Marine Mammals*. W. F. Perrin, B. Würsig and J. G. M. Thewissen. San Diego, CA, Academic Press**:** 923-931.

Weller, D. W., B. Wursig, H. Whitehead, J. C. Norris, S. K. Lynn, R. W. Davis, N. Clauss, and P. Brown (1996). Observations of an interaction between sperm whales and short-finned pilot whales in the Gulf of Mexico. *Marine Mammal Science* 12(4): 588-593.

Wells, R. S., C. A. Manire, L. Byrd, D. R. Smith, J. G. Gannon, D. Fauqiuer, and K. D. Mullin (2009). Movements and dive patterns of a rehabilitated Risso's dolphin, *Grampus griseus*, in the Gulf of Mexico and Atlantic Ocean. *Marine Mammal Science* 25(2): 420-429.

Wells, R. S., and M. D. Scott (1999). Bottlenose dolphin *Tursiops truncatus* (Montagu, 1821). In *Handbook of Marine Mammals, Volume 6: The Second Book of Dolphins and the Porpoises*. S. H. Ridgway and R. Harrison. San Diego, CA, Academic Press**:** 137-182.

Wells, R. S., and M. D. Scott (2008). Common bottlenose dolphin *Tursiops truncatus*. In *Encyclopedia of Marine Mammals*. W. F. Perrin, W. B. and J. G. M. Thewissen, Academic Press**:** 249-255.

Werth, A. J. (2006a). Mandibular and dental variation and the evolution of suction feeding in Odontoceti. *Journal of Mammalogy* 87(3): 579-588.

Werth, A. J. (2006b). Odontocete suction feeding: Experimental analysis of water flow and head shape. *Journal of Morphology* 267: 1415-1428.

West, K. L., S. Sanchez, D. Rotstein, K. M. Robertson, S. Dennison, G. Levine,and B. Jensen (2012). A Longman's beaked whale (*Indopacetus pacificus*) strands in Maui, Hawaii, with first case of morbillivirus in the central Pacific. *Marine Mammal Science*, n/a-n/a. 10.1111/j.1748-7692.2012.00616.x Retrieved from http://dx.doi.org/10.1111/j.1748-7692.2012.00616.x.

West, K. L., W. A. Walker, R. W. Baird, W. White, G. Levine, E. Brown, and D. Schofield (2009). Diet of pygmy sperm whales (*Kogia breviceps*) in the Hawiian Archipelago. *Marine Mammal Science* 25(4): 931-943.

White, M. J., J. Norris, D. Ljungblad, K. Baron, and G. di Sciara (1977). *Auditory Thresholds of Two Beluga Whales,* Delphinapterus leucas. San Diego, California, Report by Hubbs/Sea World Research Institute for Naval Ocean System Center, Report 78-109.

Whitehead, H. (2003). *Sperm Whales: Social Evolution in the Ocean*, University of Chicago Press**:** 431.

Whitehead, H., A. Coakes, N. Jaquet, and S. Lusseau (2008). Movements of sperm whales in the tropical Pacific. Marine Ecology Progress Series 361: 291-300.

Wolski, L. F., R. C. Anderson, A. E. Bowles, and P. K. Yochem (2003). Measuring hearing in the harbor seal (*Phoca vitulina*): Comparison of behavioral and auditory brainstem response techniques. *Journal of the Acoustical Society of America,* 113(1), 629-637. doi: 10.1121/1.1527961.

Wright, D. G. (1982). *A Discussion Paper on the Effects of Explosives on Fish and Marine Mammals in the Waters of the Northwest Territories*. Canadian Technical Report of Fisheries and Aquatic Sciences. (pp. 1-16). Winnipeg, Manitoba: Western Region Department of Fisheries and Oceans.

Wursig, B., T. A. Jefferson, and D. J. Schmidly (2000). *The Marine Mammals of the Gulf of Mexico*, Texas A&M University Press**:** 232.

Würsig, B., and W. J. Richardson (2009). Noise, effects of. Pp. 765–772. In Perrin, W.F., Würsig, B., and J.G.M. Thewissen, Eds. *Encyclopedia of Marine Mammals*, Ed. 2. Academic/Elsevier Press, San Diego, Ca. 1316 pp.

Yamada, T. K. (1997). Strandings of cetacea to the coasts of the Sea of Japan - with special reference to *Mesoplodon stejnegeri*. *IBI Reports* 7: 9-20.0.

Yuen, M. M. L., P. E. Nachtigall, M. Breese, and A. Y. Supin (2005). Behavioral and auditory evoked potential audiograms of a false killer whale (*Pseudorca crassidens*). *Journal of the Acoustical Society of America*, 118(4), 2688-2695.

APPENDIX A

ACOUSTIC MODELING METHODOLOGY

This page is intentionally blank.

Request for an LOA for the Incidental Taking of Marine Mammals Resulting from Long Range Strike WSEP at the Pacific Missile Range Facility at Kauai, Hawaii

Long Range Strike WSEP

MMPA and ESA Acoustic Impact Modeling: Modeling Appendix

Submitted by:

Leidos

To:

Air Force Civil Engineer Center
AFCEC/CZN

In response to tasking associated with:
Task Order CK02 under Contract W912BU-12-D-0027

Leidos Program Manager & Technical POC:

Dr. Brian Sperry

Marine Sciences R&D Division

4001 N. Fairfax Dr.

Arlington, VA 22203

Office: 703-907-2551

Fax: 703-276-3121

Email: Brian.J.Sperry@leidos.com

Request for an LOA for the Incidental Taking of Marine Mammals Resulting from Long Range Strike WSEP at the Pacific Missile Range Facility at Kauai, Hawaii

Table of Contents

List of Tables

List of Figures

APPENDIX A
MMPA AND ESA ACOUSTIC IMPACT MODELING

A.1 BACKGROUND AND OVERVIEW

A.1.1 Federal Regulations Affecting Marine Animals

All marine mammals are protected under the Marine Mammal Protection Act (MMPA). The MMPA prohibits, with certain exceptions, the take of marine mammals in U.S. waters and by U.S. citizens on the high seas and the importation of marine mammals and marine mammal products into the U.S.

The Endangered Species Act of 1973 (ESA) provides for the conservation of species that are endangered or threatened throughout all or a significant portion of their range and the conservation of their ecosystems. A species is considered endangered if it is in danger of extinction throughout all or a significant portion of its range. A species is considered threatened if it is likely to become an endangered species within the foreseeable future. Some marine mammals, already protected under MMPA, are also listed as either endangered or threatened under ESA and are afforded special protections. In addition, all sea turtles are protected under the ESA.

Actions involving sound in the water may have the potential to harass marine animals in the surrounding waters. Demonstration of compliance with the MMPA and ESA, using best available science, has been assessed using criteria and thresholds accepted or negotiated and is described here.

Sections of the MMPA (16 USC 1361 et seq.) direct the Secretary of Commerce to allow, upon request, the incidental, but not intentional, taking of small numbers of marine mammals by U.S. citizens who engage in a specified activity, other than commercial fishing, within a specified geographical region. Through a specific process, if certain findings are made and regulations are issued, or if the taking is limited to harassment, notice of a proposed authorization is provided to the public for review.

Authorization for incidental takings may be granted if the National Marine Fisheries Service (NMFS) finds that the taking will have no more than a negligible impact on the species or stock(s), will not have an immitigable adverse impact on the availability of the species or stock(s) for subsistence uses, and that the permissible methods of taking and requirements pertaining to the mitigation, monitoring, and reporting of such taking are set forth.

NMFS has defined "negligible impact" in 50 CFR 216.103 as 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 effects on annual rates of recruitment or survival.

Subsection 101(a)(5)(D) of the MMPA established an expedited process by which citizens of the United States can apply for an authorization to incidentally take small numbers of marine mammals by harassment. The National Defense Authorization Act of 2004 (NDAA) (Public Law 108-136) removed the small numbers limitation and amended the definition of "harassment" as it applies to a military readiness activity to read as follows:

> (i) *any act that injures or has the significant potential to injure a marine mammal or marine mammal stock in the wild [Level A Harassment]; or*
> (ii) *any act that disturbs or is likely to disturb a marine mammal or marine mammal stock in the wild by causing disruption of natural behavioral patterns, including, but not limited to, migration, surfacing, nursing, breeding, feeding, or sheltering, to a point where such behavioral patterns are abandoned or significantly altered [Level B Harassment].*

The primary potential impact to marine mammals from underwater acoustics is Level A and Level B harassment, as defined by the MMPA from noise. Potential impacts to sea turtles from underwater acoustic exposure are primarily behavioral responses and impairment, with some potential for injury, and a very small potential for mortality.

A.1.2 Development of Animal Impact Criteria

A.1.2.1 Marine Mammals

For explosions of ordnance planned for use in the Long Range Strike WSEP mission area, in the absence of any mitigation or monitoring measures, there is a small chance that a marine mammal could be injured or killed when exposed to the energy generated from an explosive force. Analysis of noise impacts is based on criteria and thresholds initially presented in U.S. Navy Environmental Impact Statements for ship shock trials of the Seawolf submarine and the Winston Churchill (DDG 81), and subsequently adopted by NMFS.

Mortality

Lethal impact determinations currently incorporate species-specific thresholds that are based on the level of impact that would cause extensive lung injury from which one percent of exposed animals would not recover (Finneran and Jenkins, 2012). The threshold represents the expected onset of mortality, where 99 percent of exposed animals would be expected to survive. The lethal exposure level of blast noise, associated with the positive impulse pressure of the blast, is expressed as Pascal-seconds (Pa·s) and is determined using the Goertner (1982) modified positive impulse equation. This equation incorporates sound propagation, source/animal depths, and the mass of a newborn calf of the affected species. The Goertner equation used in the acoustic model to develop mortality impact analysis, is as follows:

$$I_M(M,D) = 91.4M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/2}$$

$I_M(M,D)$	mortality threshold, expressed in terms of acoustic impulse (Pa·s)
M	Animal mass (Table D-1)
D	Water depth (m)

Level A Harassment

Non-lethal injurious impacts (Level A Harassment) are defined in those documents as onset of slight lung injury, gastro-intestinal (GI) tract damage, and permanent (auditory) threshold shift (PTS).

The criteria for onset of slight lung injury were established using partial impulse because the impulse of an underwater blast wave was the parameter that governed damage during a study using mammals, not peak pressure or energy (Yelverton, 1981). Goertner (1982) determined a way to calculate impulse values for injury at greater depths, known as the Goertner "modified" impulse pressure. Those values are valid only near the surface because as hydrostatic pressure increases with depth, organs like the lung, filled with air, compress. Therefore the "modified" impulse pressure thresholds vary from the shallow depth starting point as a function of depth.

The shallow depth starting points for calculation of the "modified" impulse pressures are mass-dependent values derived from empirical data for underwater blast injury (Yelverton, 1981). During the calculations, the lowest impulse and body mass for which slight, and then extensive, lung injury found during a previous study (Yelverton et al., 1973) were used to determine the positive impulse that may cause lung injury. The Goertner model is sensitive to mammal weight such that smaller masses have lower thresholds for positive impulse so injury and harassment will be predicted at greater distances from the source for them. The equation used for determination of slight lung injury is:

$$I_S(M,D) = 39.1M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/2},$$

where M is animal mass (in kilograms [kg]), D is animal depth (m), and the units of I_s are Pa-s. Following Finneran and Jenkins (2012), the representative mass for each species is taken to be that of an average newborn calf or pup for that species.

The criterion for slight injury to the GI tract was found to be a limit on peak pressure and independent of the animal's size (Goertner, 1982). A threshold of 103 psi (237 dB re 1 μPa) is used for all marine mammals. This level at which slight contusions to the GI tract were reported from small charge tests (Richmond et al., 1973).

Two thresholds are used for PTS, one based on sound exposure level (SEL) and the other on the sound pressure level (SPL) of an underwater blast. Thresholds follow the approach of Southall et al. (2007). The threshold producing either the largest Zone of Influence (ZOI) or higher exposure levels is then used as the more protective of the dual thresholds. In most cases, the weighted total energy flux density (EFD) is more conservative than the largest EFD in any single 1/3-octave band used in earlier models. Type II weighting functions are applied for each cetacean functional hearing group and Type I weighting functions are applied for phocids such that the PTS thresholds are as follows:

<u>Low-Frequency (LF) Cetaceans</u>

- SEL (Type II weighted): 187 decibels referenced to 1 micropascal-squared – seconds (dB re 1 $\mu Pa^2 \cdot s$)
- Peak SPL (unweighted): 230 decibels referenced to 1 micropascal (dB re 1 μPa)

<u>Mid-Frequency (MF) Cetaceans</u>

- SEL (Type II weighted): 187 dB re 1 $\mu Pa^2 \cdot s$
- Peak SPL (unweighted): 230 dB re 1 μPa

<u>High-Frequency (HF) Cetaceans</u>

- SEL (Type II weighted): 161 dB re 1 $\mu Pa^2 \cdot s$
- Peak SPL (unweighted): 201 dB re 1 μPa

<u>Phocids (In-Water)</u>

- SEL (Type I weighted) of 192 dB re 1 $\mu Pa^2 \cdot s$
- Peak SPL (unweighted) of 218 dB re 1 μPa

<u>Level B Harassment</u>

Level B (non-injurious) harassment includes temporary (auditory) threshold shift (TTS), a slight, recoverable loss of hearing sensitivity. One criterion used for TTS, the total Type II weighted EFD of the signal, is a threshold of 172 dB re 1 μPa^2-s for LF and MF cetaceans. A second criterion, a maximum allowable peak pressure of 23 psi (224 dB re 1 μPa), has recently been established by NMFS to provide a more conservative range for TTS when the explosive or animal approaches the sea surface, in which case explosive energy is reduced but the peak pressure is not. NMFS applies the more conservative of these two. For species where no data exist, TTS thresholds are based on the most closely related species for which data are available. The TTS thresholds for each functional hearing group are as follows:

LF Cetaceans

- SEL (Type-II weighted) of 172 dB re 1 μPa^2·s
- Peak SPL (unweighted) of 224 dB re 1 μPa

MF Cetaceans

- SEL (Type II weighted) of 172 dB re 1 μPa^2·s
- Peak SPL (unweighted) of 224 dB re 1 μPa

HF Cetaceans

- SEL (Type II weighted) of 146 dB re 1 μPa^2·s
- Peak SPL (unweighted) of 195 dB re 1 μPa

Phocids (In-Water)

- SEL (Type I weighted) of 177 dB re 1 μPa^2·s
- Peak SPL (unweighted) of 212 dB re 1 μPa

Level B Behavioral Harassment

For multiple successive explosions, the acoustic criterion for non-TTS behavioral disturbance is used to account for behavioral effects significant enough to be judged as harassment but occurring at lower sound energy levels than those that may cause TTS. The threshold for behavioral disturbance is set 5 dB below the Type II weighted total EFD-based TTS threshold, or 167 dB re 1 μPa^2-s. This is based on observations of behavioral reactions in captive dolphins and belugas occurring at exposure levels approximately 5 dB below those causing TTS after exposure to pure tones (Schlundt et al., 2000). The behavioral impacts thresholds for all functional hearing groups of marine mammals exposed to multiple, successive detonations are:

LF Cetaceans

- SEL (Type II weighted) of 167 dB re 1 μPa^2·s

MF Cetaceans

- SEL (Type II weighted) of 167 dB re 1 μPa^2·s

HF Cetaceans

- SEL (Type II weighted) of 141 dB re 1 μPa^2·s

Phocids (In-Water)

- SEL (Type I weighted) of 172 dB re 1 μPa^2·s

Table A-1 summarizes the current threshold levels for marine mammals used to analyze explosives identified for use in the Long Range Strike WSEP mission area. The mammal species of interest for Long Range Strike WSEP are spread across four functional hearing groups, three for cetaceans – low frequency (LF), mid-frequency (MF) and high frequency (HF) – and one for in-water phocids.

Table A-1. Explosives Threshold Levels for Marine Mammals

<table>
<tr><th rowspan="2">Functional Hearing Group</th><th rowspan="2">Mortality*</th><th colspan="3">Level A Harassment</th><th colspan="2">Level B Harassment</th></tr>
<tr><th>Slight Lung Injury*</th><th>GI Tract Injury</th><th>PTS</th><th>TTS</th><th>Behavioral</th></tr>
<tr><td rowspan="2">LF Cetaceans</td><td rowspan="4">$91.4M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/2}$</td><td rowspan="4">$39.1M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/2}$</td><td rowspan="2">Unweighted SPL: 237 dB re 1 μPa</td><td>Weighted SEL: 187 dB re 1 μPa^2·s</td><td>Weighted SEL: 172 dB re 1 μPa^2·s</td><td rowspan="2">Weighted SEL: 167 dB re 1 μPa^2·s</td></tr>
<tr><td>Unweighted SPL: 230 dB re 1 μPa</td><td>Unweighted SPL: 224 dB re 1 μPa (23 psi PP)</td></tr>
<tr><td rowspan="2">MF Cetaceans</td><td rowspan="2">Unweighted SPL: 237 dB re 1 μPa</td><td>Weighted SEL: 187 dB re 1 μPa^2·s</td><td>Weighted SEL: 172 dB re 1 μPa^2·s</td><td rowspan="2">Weighted SEL: 167 dB re 1 μPa^2·s</td></tr>
<tr><td>Unweighted SPL: 230 dB re 1 μPa</td><td>Unweighted SPL: 224 dB re 1 μPa (23 psi PP)</td></tr>
</table>

Table A-1. Explosives Threshold Levels for Marine Mammals, Cont'd

Functional Hearing Group	Mortality*	Level A Harassment			Level B Harassment	
		Slight Lung Injury*	GI Tract Injury	PTS	TTS	Behavioral
HF Cetaceans			Unweighted SPL: 237 dB re 1 μPa	Weighted SEL: 161 dB re 1 $\mu Pa^2 \cdot s$	Weighted SEL: 146 dB re 1 $\mu Pa^2 \cdot s$	Weighted SEL: 141 dB re 1 $\mu Pa^2 \cdot s$
				Unweighted SPL: 201 dB re 1 μPa	Unweighted SPL: 195 dB re 1 μPa (1 psi PP)	
Phocids (in water)			Unweighted SPL: 237 dB re 1 μPa	Weighted SEL: 192 dB re 1 $\mu Pa^2 \cdot s$	Weighted SEL: 177 dB re 1 $\mu Pa^2 \cdot s$	Weighted SEL: 172 dB re 1 $\mu Pa^2 \cdot s$
				Unweighted SPL: 218 dB re 1 μPa	Unweighted SPL: 212 dB re 1 μPa (6 psi PP)	

M = Animal mass based on species (kilograms); *D* = Water depth (meters); dB re 1 μPa = decibels referenced to 1 micropascal; dB re 1 $\mu Pa^2 \cdot s$ = decibels referenced to 1 micropascal-squared – seconds; GI = gastrointestinal; PTS = permanent threshold shift; SEL = sound exposure level; TTS = temporary threshold shift; SPL = sound pressure level; PP = peak pressure
*Expressed in terms of acoustic impulse (pascal – seconds [Pa·s])

A.1.2.2 Sea Turtles

The weapons impact zone will be located in an area that is inhabited by species listed as threatened or endangered under the ESA (16 USC §§ 1531-1543), including sea turtles. Operation of sound sources, that is, transmission of acoustic signals in the water column, could potentially cause harm or harassment to listed species.

Until recently, there were no acoustic energy or pressure impact thresholds defined specifically for ESA-listed sea turtles and, in the absence of such information, the thresholds used for marine mammal analysis were typically applied. However, NMFS has recently undertaken a more detailed investigation of the effects of underwater detonations on turtles and provided the following summary of potential behavioral responses at various peak dB levels (Table A-2).

Table A-2. Range of Sea Turtle Behavioral Responses at Multiple Underwater Noise Levels

dB Level (Peak) Range	Response Category	Number of Animals Potentially Affected
110 – 160	Discountable effects; minor response possible but within the range of normal behaviors.	Very few
>160 – 200	Some swimming and diving response, becoming stronger and more frequent at higher dB levels.	Few at 160 dB; most at 200 dB
>200 – 220	Strong avoidance response.	Some to all at 220 dB
>220	Intolerable.	All individuals

dB = decibel

Although there has been recent effort to address turtle-specific thresholds, there are currently no experimental or modeling data sufficient to support development of physiological thresholds. However, NMFS has recently endorsed sea turtle criteria and thresholds for impulsive sources (including detonations) to be used in impact analysis. In some cases, turtle-specific data are not available and marine mammal criteria are therefore used. Similar to marine mammal analysis, criteria and thresholds are provided for mortality (extensive lung injury), non-lethal injury (slight lung or GI tract injury), onset of PTS and TTS, and behavioral effects (Finneran and Jenkins, 2012).

Table A-3. Criteria and Thresholds Used for Sea Turtle Exposure Impulsive Impact Analysis

Impulsive Sound Exposure Impact	Threshold Value
Onset Mortality (1% mortality based on extensive lung injury)*	$91.4M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/2}$
Onset Slight Lung Injury*	$39.1M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/2}$
Onset Slight Gastrointestinal Tract Injury	237 dB re 1 µPa SPL (104 psi)
Onset Permanent Threshold Shift	187 dB re 1 µPa^2-s SEL (T^2)
	230 dB re 1 µPa Peak SPL
Onset Temporary Threshold Shift	172 dB re 1 µPa^2-s SEL (T^2)
	224 dB re 1 µPa Peak SPL
Behavioral Effects	175 dB re 1 µPa unweighted RMS

D = depth of animal (meters); dB = decibel; dB re 1 µPa = decibels referenced to 1 micropascal; dB re 1 µPa^2·s = decibels referenced to 1 micropascal-squared second; M = animal mass based on species (kilograms); RMS = root mean square; SEL = sound exposure level; SPL = sound pressure level; T = turtle auditory weighting
*Expressed in terms of acoustic impulse (pascal seconds [Pa-s])

A.2 EXPLOSIVE ACOUSTIC SOURCES

A.2.1 Acoustic Characteristics of Explosive Sources

The acoustic sources to be deployed during Long Range Strike WSEP missions are categorized as broadband explosives. Broadband explosives produce significant acoustic energy across several frequency decades of bandwidth. Propagation loss is sufficiently sensitive to frequency as to require model estimates at several frequencies over such a wide band.

Explosives are impulsive sources that produce a shock wave that dictates additional pressure-related metrics (peak pressure and positive impulse). Detailed descriptions of the sources in the Long Range Strike WSEP mission area are provided in this subsection.

Explosives detonated underwater introduce loud, impulsive, broadband sounds into the marine environment. Three source parameters influence the effect of an explosive: the weight of the explosive material, the type of explosive material, and the detonation depth. The net explosive weight (or NEW) accounts for the first two parameters. The NEW of an explosive is the weight of TNT required to produce an equivalent explosive power.

A.2.2 Animal Harassment Effects of Explosive Sources

The harassments expected to result from these sources are computed on a per-event basis, where an event lasts for 24 hours and takes into account multiple explosives that would detonate within that time period. Within that 24-hour time period it is assumed that the animal population remains constant or, in other words, animals exposed to sounds at the beginning of the 24-hour period would also be exposed to any sounds occurring at the end of the period. A new animal population is assumed for each consecutive 24-hour period. In some cases, this can be a more conservative approach than assuming each detonation, or burst of detonations, is received by a new population of animals. It is important to note that only energy metrics are affected by the accumulation of energy over a 24-hour period. Pressure metrics (e.g., peak pressure and positive impulse) do not accumulate. Rather, a maximum is taken over all of the detonations specified within the 24-hour period. A more detailed description of pressure and energy considerations resulting from munition bursts is provided in Section A.2.3 below.

Explosives are modeled as detonating at depths ranging from the water surface to 10 feet below the surface, as provided by government-furnished information. Impacts from above surface detonations were considered negligible and not modeled.

For sources that are detonated at shallow depths, it is frequently the case that the explosion may breach the surface with some of the acoustic energy escaping the water column. We model surface detonations as occurring 1 foot below the water surface. The source levels have not been adjusted for possible venting nor does the subsequent analysis attempt to take this into account.

A.2.3 Zone of Influence: Per-Detonation Versus Net Explosive Weight Combination

It may useful to consider why and when it is appropriate to treat rounds within a burst as separate events, rather than combining the NEW of all rounds and treating it as a single, larger event. The basic information necessary to address this issue is provided below, where pressure-based metrics are considered separately from energy-level metrics.

Peak Pressure and Positive Impulse

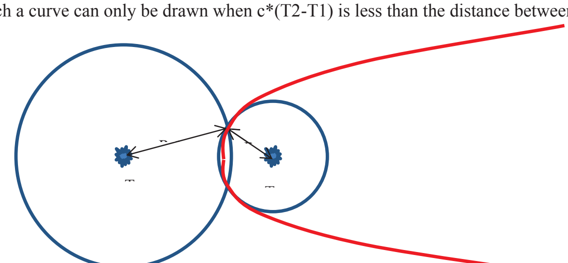
Peak pressures add if two (or more) impulses reach the same point at the same time. Since explosive rounds go off at different times and locations, this will only be true for a small set of points. This problem is mathematically the same as the passive sonar problem of localizing a sound source based on the time difference of arrival (TDOA) of a signal reaching two receivers (R1 and R2). The red curve in the figure (half of a hyperbola) represents the set of all points where:

R1 – R2 = c*(T2 – T1), for

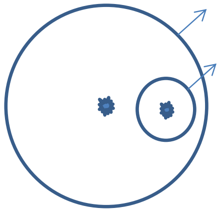
c = the speed of sound in water, and

T1 and T2 being the detonation times of the two rounds.

Such a curve can only be drawn when c*(T2-T1) is less than the distance between the two explosions. If,



for instance, 30 rounds/second are fired (and the difference in impact time is assumed to be roughly the distance in firing time), then the peak impact pressure from the first round will have traveled 1,500 meters/second * 1/30 second = 50 meters. If the second round hits less than 50 meters from the first round, the impact wave from the second round will never catch the impact wave from the first.



In the first case (loose grouping), the pressures will only add along a curve with very narrow width and negligible volume. The pressure on this curve is less than twice the pressure of the closest round, as it will be the pressure at R2 and at (R2+c*dT). In the second case (tight grouping), the pressures will never add.

If this logic is extended to a many-shot burst, the logic becomes even more persuasive. For the impulse peak from a third shot to interact with the peaks from the first two using the 30 rounds/second assumption, it would have to impact the water more than 100 meters away from the impact of the first round and more than 50 meters away from the impact of the second round. Even in that case, there would be at most two places in the ocean where the curve from the 1st and 3rd impacts would meet the curve from 2nd and 3rd explosions (and the travel distances would have to be 50 meters longer for one and 100 meters longer for the other). In summary:

- There would be 0 to 4 directions where a curve (a hyperbola approaches an asymptotic line far from the source) of negligible thickness, and volume would have less than two times the pressure from the closest source.
- There would be 0 to 2 very small points with no extent in range or bearing where one would see less than three times the pressure from the closest source.
- In every other part of the ZOI, the impulse from each round would be received separately by any animal present.

For the 4th round and any subsequent round, another curve could be added, if it was far enough away from the previous shots so that their peak had not already passed the impact point. However, this new curve would intersect with the previous two curves at a different location than where the first two curves intersected. No matter how many rounds are fired, there would not be any point in the ocean where more than three peaks arrive at the same time. These points would have almost no volumetric extent, and required range increases from the closest source of N*dt*c, where *N* is the difference in shot number and *dt* is the time between shots.

If the rate of fire is increased, there is a decrease in the additional required separation in order to have any coherent increase in pressure or positive impulse. However, the end result is that almost all of the ocean experiences only one pressure peak at a time.

If the rounds are far enough apart in space and close enough in time, there will be curves where sequential rounds add coherently; however,

- They will not occupy any significant volume, and
- They will be less than a factor of 2 above the pressure or positive impulse of the nearest source.

Contrast this with the alternative assumption that pressures from separate rounds are added. This models the event as if all rounds went off exactly at the same place and exactly at the same time. That is the only way that travelling pressure peaks from separate rounds would go through space together and add pressures at all points. This is not realistic and would overestimate pressure and positive impulse metrics by a factor equal to the number of rounds in the burst, which could be 10 or 20 dB in pressure levels.

Energy Metrics

Energy metrics accumulate the integral of the power density of each explosion over the duration of the impulse. Thus, even though the peaks from separate explosions arrive at different times, the energy from all of their arrivals will be added. If you fire a number of rounds close together in a burst (N_{burst}), the energy from all of the rounds will add and the sound exposure level will be 10*log10(N_{burst}) higher than if a single shot had been fired. The area affected, A_{burst}, would be larger than the area affected by a single shot (A_1), because additional transmission loss would be needed to reduce the larger energy level to a given threshold.

The alternative assumption is that each round sees a fresh population and the area affected by N single bullets is $N*A_1$. The single-shot assumption is more conservative as long as $A_{burst} < N*A_1$.

A.3 ENVIRONMENTAL CHARACTERIZATION

A.3.1 Important Environmental Parameters for Estimating Animal Harassment

Propagation loss ultimately determines the extent of the ZOI for a particular source activity. In turn, propagation loss as a function of range depends on a number of environmental parameters including:

- Water depth
- Sound speed variability throughout the water column
- Bottom geo-acoustic properties
- Surface roughness, as determined by wind speed

Due to the importance that propagation loss plays in anti-submarine warfare, the Navy has, over the last four to five decades, invested heavily in measuring and modeling these environmental parameters. The result of this effort is the following collection of global databases containing these environmental parameters, which are accepted as standards for Navy modeling efforts. Table A-4 contains the version of the databases used in the modeling for this report.

Table A-4. Navy Standard Databases Used in Modeling

Parameter	Database	Version
Water Depth	Digital Bathymetry Data Base Variable Resolution	DBDBV 6.0
Ocean Sediment	Re-packed Bottom Sediment Type	BST 2.0
Wind Speed	Surface Marine Gridded Climatology Database	SMGC 2.0
Temperature/Salinity Profiles	Generalized Digital Environment Model	GDEM 3.0

The sound speed profile directs the sound propagation in the water column. The spatial variability of the sound speed field is generally small over operating areas of typical size. The presence of a strong oceanographic front is a noteworthy exception to this rule. To a lesser extent, variability in the depth and strength of a surface duct can be of some importance. If the sound speed minimum occurs within the water column, more sound energy can travel further without suffering as much loss (ducted propagation). But if the sound speed minimum occurs at the surface or bottom, the propagating sound interacts more with these boundaries and may become attenuated more quickly. In the mid-latitudes, seasonal variation often provides the most significant variation in the sound speed field. For this reason, both summer and winter profiles are modeled to demonstrate the extent of the difference.

Losses of propagating sound energy occur at the boundaries. The water-sediment boundary defined by the bathymetry can vary by a large amount. In a deep water environment, the interaction with the bottom may matter very little. In a shallow water environment the opposite is true and the properties of the sediment become very important. The sound propagates through the sediment, as well as being reflected by the interface. Soft (low-density) sediment behaves more like water for lower frequencies and the sound has relatively more transmission and relatively less reflection than a hard (high-density) bottom or thin sediment.

The roughness of the boundary at the water surface depends on the wind speed. Average wind speed can vary seasonally but could also be the result of local weather. A rough surface scatters the sound energy and increases the transmission loss. Boundary losses affect higher frequency sound energy much more than lower frequencies.

A.3.2 Characterizing the Acoustic Marine Environment

The environment for modeling impact value is characterized by a frequency-dependent bottom definition, range-dependent bathymetry and sound velocity profiles (SVP), and seasonally varying wind speeds and SVPs. The bathymetry database is on a grid of variable resolution.

The SVP database has a fixed spatial resolution storing temperature and salinity as a function of time and location. The low-frequency bottom loss is characterized by standard definition of geo-acoustic parameters for the given sediment type for the area. The high-frequency bottom loss class is fixed to match expected loss for the sediment type. The area of interest can be characterized by the appropriate sound speed profiles, set of low-frequency bottom loss parameters, high-frequency bottom loss class, and HFEVA very-high-frequency sediment type for modeled frequencies in excess of 10 kilohertz (kHz).

Generally, seasonal variation is sampled by looking at summer and winter cases that tend to capture extremes in both the environmental variability as well as animal populations. Calculations were made for both seasons, even though events are expected to be at the end of the summer season.

Impact volumes in the operating area are then computed using propagation loss estimates and the explosives model derived for the representative environment.

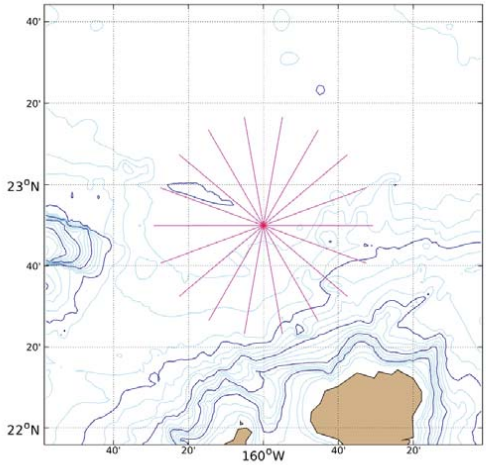
A.3.3 Description of the BSURE Training Range Area Environment

The Long Range Strike mission area is located to the northwest of the Hawaiian island of Kauai, in the northern part of the BSURE tracking range. The bottom is characterized as clay according to the Bottom Sediments Type Database. Environmental values were extracted from unclassified Navy standard databases in a radius of 75 kilometers around the center point at

N 22° 50.0' W 160° 00'

The Navy standard database for bathymetry has a resolution of 0.05 minutes in the Pacific Ocean; see Figure A-1. Mean and median depths from DBDBV in the extracted area are 4,351 and 4,550 meters, respectively. Minimum and maximum depths are 1,135 and 4,848 meters, respectively.

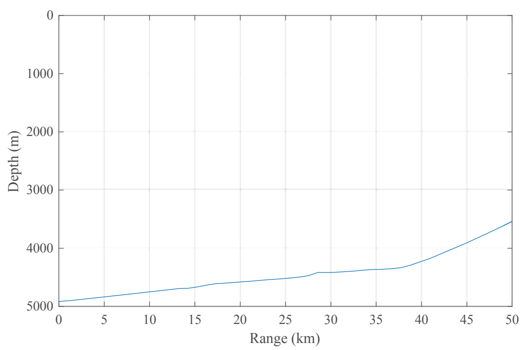
Figure A-1. Bathymetry (in 250-Meter Contours) for the BSURE Range and Long Range Strike WSEP Mission Area



The seasonal variability in wind speed was modeled as 7.7 knots in the summer and 7.1 knots in the winter.

Example input of range-dependent bathymetry is depicted in Figure A-2 for the due-north bearing.

Figure A-2. Bathymetry Along 150° Radial to the SW from Center Point



A.4 MODELING IMPACT ON MARINE ANIMALS

Many underwater actions include the potential to injure or harass marine animals in the neighboring waters through noise emissions. The number of animals exposed to potential harassment in any such action is dictated by the propagation field and the characteristics of the noise source.

Estimating the number of animals that may be injured or otherwise harassed in a particular environment entails the following steps.

- For the relevant environmental acoustic parameters, transmission loss (TL) estimates are computed, sampling the water column over the appropriate depth and range intervals. TL calculations are also made over disjoint one-third octave bands for a wide range of frequencies with dependence in range, depth, and azimuth for bathymetry and sound speed. TL computations were sampled with 40-degree spacing in azimuth.
- The Type II weighted total accumulated energy within the waters where the source detonates is sampled over a volumetric grid. At each grid point, the received energy from each source emission is modeled as the effective energy source level reduced by the appropriate propagation loss from the location of the source at the time of the emission to that grid point and summed. For the peak pressure or positive impulse, the appropriate metric is similarly modeled for each emission. The maximum value of that metric over all frequencies and emissions is stored at each grid point.
- The impact volume for a given threshold is estimated by summing the incremental volumes represented by each grid point sampled in range and depth for which the appropriate metric exceeds that threshold and accumulated over all modeled bearings. Histograms representing impact volumes as a function of (possibly depth-dependent) thresholds are stored in a spreadsheet for dynamic changes of thresholds.
- Finally, the number of harassments is estimated as the inner-product of the animal density, the impact area, and number of events per year.

This section describes in detail the process of computing impact areas.

A.4.1 Calculating Transmission Loss

Transmission loss (TL) was pre-computed for both seasons for 30 non-overlapping frequency bands. The 30 bands had one-third octave spacing around center frequencies from 50 Hertz (Hz) to approximately 40.637 kHz. In the previous report, TL was computed at only seven frequencies. The broadband nature of the sources has been well covered in this report. The TL was modeled using the Navy Standard GRAB V3 propagation loss model (Keenan, 2000) with CASS v4.3. GRAB is well suited to modeling transmission losses over the wide frequency band of interest.

The TL results were interpolated onto a variable range grid with logarithmic spacing. The increased spatial resolution near the source provided greater fidelity for estimates.

The TL was calculated from the source depth to an array of output depths. The output depths were the mid-points of depth intervals matching GDEM's depth sampling. For water depths from surface to 10-meter depth, the depth interval was 2 meters. Between 10-meter and 100-meter water depth, the depth interval was 5 meters. For waters greater than 100 meters, the depth interval was 10 meters. For the BSURE area environment, there were 45 depth bins spanning 0 to 1,000 meters. The output depths represent possible locations of the animals and are used with the animal depth distribution to better estimate animal impact. The depth grid is used to make the surface image interference correction and to capture the depth-dependence of the positive impulse threshold.

A.4.2 Computing Impact Areas

This section and the next provide a detailed description of the approach taken to compute impact areas for explosives. The impact volume associated with a particular activity is defined as the area of water in which some acoustic metric exceeds a specified threshold. The product of this impact area and animal density yields the expected value of the number of animals exposed to that acoustic metric at a level that exceeds the threshold. The acoustic metric can either be an energy term (weighted or un-weighted energy flux density, either in a limited frequency band or across the full band) or a pressure term (such as peak pressure or positive impulse). The thresholds associated with each of these metrics define the levels at which half of the animals exposed will experience some degree of harassment (ranging from behavioral change to mortality).

Impact area is particularly relevant when trying to estimate the effect of repeated source emissions separated in either time or space. Impact range, which is defined as the maximum range at which a particular threshold is exceeded either for a single source emission or accumulation of source emissions over a 24-hour period, defines the range to which marine mammal activity is monitored in order to meet mitigation requirements. Based on the latest guidance, this impact range is also used to provide conservative two-dimensional calculations of the exposure estimates by simply by multiplying the impact area by the animal density and the total number of events proposed each year. Refer to Section A.5.1. This two-dimensional, maximum-range approach conservatively assumes that all ranges and depths, out to the maximum range, are above the threshold. In deep water environments with near-surface sources, this is a particularly conservative approach as it does not consider shadow zones where sound levels are greatly diminished due to vertical gradients in the speed of sound within the water column.

The effective energy source level is modeled directly for the sources to be used at the BT-9 target area. The energy source level is comparable to the model used for other explosives (Arons (1954), Weston (1960), McGrath (1971), Urick (1983), Christian and Gaspin (1974)). The energy source level over a one-third octave band with a center frequency of f for a source with a net explosive weight of w pounds is given by:

$$\mathrm{ESL} = 10 \log_{10} (0.26 f) + 10 \log_{10} (2\, p_{max}^2 / [1/\theta^2 + 4 \pi^2 f^2]) + 197 \text{ dB}$$

where the peak pressure for the shock wave at 1 meter is defined as

$$p_{max} = 21600 \,(w^{1/3} / 3.28)^{1.13} \text{ psi} \qquad \text{(B-1)}$$

and the time constant is defined as:

$$\theta = [(0.058)\,(w^{1/3})\,(3.28 / w^{1/3})^{0.22}] / 1000 \text{ sec} \qquad \text{(B-2)}$$

For each explosive source, the amount of acoustic energy injected into the water column is calculated, conservatively assuming that all explosive energy is converted into acoustic energy. The propagation loss for each frequency, expressed as a pressure term, modulates the sound energy found at each point on the grid of depth (uniform spacing) and range (logarithmic spacing). If a threshold is exceeded at a point, the impact volume at an annular sector is added to the total impact volume. The impact volume at a point is calculated exactly using the depth, range, and azimuthal intervals associated with that particular point in the water column.

A.4.3 Effects of Metrics on Impact Areas

The impact of explosive sources on marine wildlife is measured by three different metrics, each with its own thresholds. The energy metric, the peak pressure metric, and the “modified” positive impulse metric are discussed in this section. The energy metric, using the Type II weighted total energy, is accumulated after the explosive detonation. The other two metrics, peak pressure and positive impulse, are not accumulated but rather the maximum levels are taken.

Energy Metric

The energy flux density is sampled at several frequencies in one-third-octave bands. The total weighted energy flux at each range/depth combination is obtained by summing the product of the Type II frequency weighting function, $W_{II}(f)$, and the energy flux density at each frequency. The type II weighting function in dB is given by:

$$\boldsymbol{W_{II}(f) = maximum\big(G_1(f), G_{12}(f)\big)}, \text{ where}$$

$$\boldsymbol{G_1(f) = K_1 + 20log_{10}\left[\frac{b_1^2 f^2}{(a_1^2+f^2)(b_1^2+f^2)}\right]}, \text{ and}$$

$$\boldsymbol{G_2(f) = K_2 + 20log_{10}\left[\frac{b_2^2 f^2}{(a_2^2+f^2)(b_2^2+f^2)}\right]}.$$

The component lower cutoff frequencies, a_1 and a_2, upper cutoff frequencies, b_1 and b_2, and gains, K_1 and K_2, are a function of the functional hearing group. Parameters used for cetaceans are given in Table A-5.

Table A-5. Type II Weighting Parameters Used for Cetaceans

Functional Hearing Group	K_1(dB)	a_1(Hz)	b_1(Hz)	K_2(dB)	a_2(Hz)	b_2(Hz)
LF cetaceans	-16.5	7	22,000	0.9	674	12,130
MF cetaceans	-16.5	150	160,000	1.4	7,829	95,520
HF cetaceans	-19.4	200	180,000	1.4	9,480	108,820

Note that because the weightings are in dB, we will actually weight each frequency's EFD by $10^{(W_{II}(f)/10)}$, sum the EFDs over frequency, and then convert the weighted total energy to back to dB, with level = 10 $\log_{10}$(total weighted EFD).

Phocids and sea turtles use a simpler, Type I, weighting function to represent their hearing sensitivities. The weighting function is the same as that given above for G_1, with K_1 set to zero and a_1 and b_1 given below in Table A-6.

Table A-6. Type I Weighting Parameters for Phocids and Sea Turtles

Functional Hearing Group	a(Hz)	b(Hz)
Phocids (In-Water)	75	75,000
Sea Turtles	75	2,000

Peak Pressure Metric

The peak pressure metric is a simple, straightforward calculation at each range/animal depth combination. First, the transmission pressure ratio, modified by the source level in a one-third-octave band, is summed across frequency. This averaged transmission ratio is normalized by the total broadband source level. Peak pressure at that range/animal depth combination is then simply the product of:

- The square root of the normalized transmission ratio of the peak arrival,
- The peak pressure at a range of 1 meter (given by equation B-1), and
- The similitude correction (given by $r^{-0.13}$, where r is the slant range).

If the peak pressure for a given grid point is greater than the specified threshold, then the incremental volume for the grid point is added to the impact volume for that depth layer.

"Modified" Positive Impulse Metric

The modeling of positive impulse follows the work of Goertner (Goertner, 1982). The Goertner model defines a "partial" impulse as

$$I = \int_0^{T_{min}} p(t)dt \,,$$

where $p(t)$ is the pressure wave from the explosive as a function of time t, defined so that $p(t) = 0$ for $t < 0$. This similitude pressure wave is modeled as

$$p(t) = p_{max}\, e^{-t/\theta}$$

where p_{max} is the peak pressure at 1 meter (see, equation B-1), and θ is the time constant defined in equation A-2.

The upper limit of the "partial" impulse integral is

$$T_{min} = \min \{T_{cut}, T_{osc}\}$$

where T_{cut} is the time to cutoff and T_{osc} is a function of the animal lung oscillation period. When the upper limit is T_{cut}, the integral is the definition of positive impulse. When the upper limit is defined by T_{osc}, the integral is smaller than the positive impulse and thus is just a "partial" impulse. Switching the integral limit from T_{cut} to T_{osc} accounts for the diminished impact of the positive impulse upon the animals lungs that compress with increasing depth and leads to what is sometimes call a "modified" positive impulse metric.

The time to cutoff is modeled as the difference in travel time between the direct path and the surface-reflected path in an isovelocity environment. At a range of r, the time to cutoff for a source depth z_s and an animal depth z_a is

$$T_{cut} = 1/c \; \{ \, [r^2 + (z_a + z_s)^2]^{1/2} - [r^2 + (z_a - z_s)^2]^{1/2} \, \}$$

where c is the speed of sound.

The animal lung oscillation period is a function of animal mass M and depth z_a and is modeled as

$$T_{osc} = 1.17\, M^{1/3}\, (1 + z_a/33)^{-5/6}$$

where M is the animal mass (in kg) and z_a is the animal depth (in feet).

The modified positive impulse threshold is unique among the various injury and harassment metrics in that it is a function of depth and the animal weight. So instead of the user specifying the threshold, it is computed as $K\,(M)^{1/3}\,(1 + z_a/33)^{1/2}$. The coefficient K depends upon the level of exposure. For the onset of slight lung injury, K is 39.1; for the onset of extensive lung hemorrhaging (1 percent mortality), K is 91.4.

Although the thresholds are a function of depth and animal weight, sometimes they are summarized as their value at the sea surface for a typical dolphin calf (with an average mass of 12.2 kg). For the onset of slight lung injury, the threshold at the surface is approximately 13 psi-msec; for the onset of extensive lung hemorrhaging (1 percent mortality), the threshold at the surface is approximately 31 psi-msec.

As with peak pressure, the "modified" positive impulse at each grid point is compared to the derived threshold. If the impulse is greater than that threshold, then the incremental volume for the grid point is added to the impact volume for that depth layer.

A.5 ESTIMATING ANIMAL HARASSMENT

A.5.1 "Two-Dimensional" Harassment Estimates

If one does not have confidence in the depth-distribution of animals within the water column, then a more conservative approach to estimating harassment is to compute only a two-dimensional impact. In this approach, the impact volume is essentially a cylinder extending from the surface to the seafloor, centered at the sound source and with a radius set equal to the maximum range, R_{max}, across all depths and azimuths at which the particular metric level is still above threshold. The number of animals impacted is computed simply by multiplying the area of a circle with radius R_{max} by the original animal density given in animals per square kilometer. Impacts computed in this manner will always exceed or equal impacts based on depth-dependent animal distributions.

A.6 REFERENCES

Arons, A. B. (1954). "Underwater Explosion Shock Wave Parameters at Large Distances from the Charge," *J. Acoust. Soc. Am*. 26, 343.

Bartberger, C. L. (1965). "Lecture Notes on Underwater Acoustics," NADC Report NADC=WR-6509, Naval Air Development Center Technical Report, Johnsville, PA, 17 May (AD 468 869) (UNCLASSIFIED).

Christian, E. A., and J. B. Gaspin (1974). Swimmer Safe Standoffs from Underwater Explosions," NSAP Project PHP-11-73, Naval Ordnance Laboratory, Report NOLX-89, 1 July (UNCLASSIFIED).

Department of the Navy (1998). "Final Environmental Impact Statement, Shock Testing the SEAWOLF Submarine," U.S. Department of the Navy, Southern Division, Naval Facilities Engineering Command, North Charleston, SC, 637 p.

Department of the Navy (2001). "Final Environmental Impact Statement, Shock Trial of the WINSTON S. CHURCHILL (DDG 81)," U.S. Department of the Navy, NAVSEA, 597 p.

DeRuiter, S. L., and K. L. Doukara (2012). Loggerhead turtles dive in response to airgun sound exposure. *Endangered Species Research*, Volume 16:55-63. January 18, 2012.

Finneran, J. J., R. Dear, D. A. Carder, and S. H. Ridgway (2002). Temporary shift in masked hearing thresholds in odontocetes after exposure to single underwater impulses from a seismic watergun. *Journal of the Acoustical Society of America*. 111:2929-2940.

Finneran, J. J., and C. E. Schlundt (2004). Effects of intense pure tones on the behavior of trained odontocetes. Space and Naval Warfare Systems Center, San Diego, Technical Document. September.

Finneran, J. J., D. A. Carder, C. E. Schlundt, and S. H. Ridgway (2005). Temporary threshold shift in bottlenose dolphins (Tursiops truncatus) exposed to mid-frequency tones. *Journal of Acoustical Society of America*. 118:2696-2705.

Finneran, J. J., and A. K. Jenkins (2012). Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis. U.S. Navy, SPAWAR Systems Center. April 2012.

Goertner, J. F. (1982). "Prediction of Underwater Explosion Safe Ranges for Sea Mammals," NSWC TR 82-188, Naval Surface Weapons Center, Dahlgren, VA.

Keenan, R. E., D. Brown, E. McCarthy, H. Weinberg, and F. Aidala (2000). "Software Design Description for the Comprehensive Acoustic System Simulation (CASS Version 3.0) with the Gaussian Ray Bundle Model (GRAB Version 2.0)," NUWC-NPT Technical Document 11,231, Naval Undersea Warfare Center Division, Newport, RI, 1 June (UNCLASSIFIED).

Ketten, D. R. (1998). Marine mammal auditory systems: A summary of audiometric and anatomical data and its implications for underwater acoustic impacts. NOAA-TM-NMFS-SWFSC-256, Department of Commerce.

Kryter, K. D., W. D. Ward, J. D. Miller, and D. H. Eldredge (1966). Hazardous exposure to intermittent and steady-state noise. *Journal of the Acoustical Society of America*. 48:513-523.

McCauley, R. D., J. Fewtrell, A. J. Duncan, C. Jenner, M.-N. Jenner, J. D. Penrose, R. I. T. Prince, A. Adhitya, J. Murdoch, and K. McCabe (2000). *Marine seismic surveys: analysis and propagation of air-gun signals; and effects of air-gun exposure on humpback whales, sea turtles, fishes and squid*. CMST 163, Report R99-15, prepared for the Australian Petroleum Production Exploration Association from the Centre for Marine Science and Technology, Curtin University, Perth, Western Australia.

McGrath, J. R. (1971). "Scaling Laws for Underwater Exploding Wires," *J. Acoust. Soc. Am*., 50, 1030-1033 (UNCLASSIFIED).

Miller, J. D. (1974). Effects of noise on people. *Journal of the Acoustical Society of America*. 56:729–764.

Nachtigall, P. E., J. L. Pawloski, and W. W. L. Au (2003). Temporary threshold shift and recovery following noise exposure in the Atlantic bottlenose dolphin (Tursiops truncatus). *Journal of the Acoustical Society of America*, 113:3425-3429.

National Oceanic and Atmospheric Administration (NOAA) (2015). "DRAFT Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing," Revised version for Second Public Comment Period, 180 p.

Richmond, D. R., J. T. Yelverton, and E. R. Fletcher (1973). "Far-field underwater-blast injuries produced by small charges," DNA 3081T. Lovelace Foundation for Medical Education and Research, Defense Nuclear Agency: Washington, D.C.

Schlundt, C. E., J. J. Finneran, D. A. Carder, and S. H. Ridgway (2000). Temporary shift in masked hearing thresholds of bottlenose dolphins, Tursiops truncatus, nd white whales, Delphinapterous leucas, after exposure to intense tones. *Journal of the Acoustical Society of America*. 107:3496-3508.

Southall, B. L., A. E. Bowles, W. T. Ellison, J. J. Finneran, R. L. Gentry, C. R. Greene,, Jr., D. Kastak, D. R. Ketten, J. H. Miller, P. E. Nachtigall, W. J. Richardson, J. A. Thomas, and P. L. Tyack, (2007). "Marine mammal noise exposure criteria: initial scientific recommendations," *Aquatic Mammals*, 33, 411-521.

Urick, R. J. (1983. Principles of Underwater Sound for Engineers, McGraw-Hill, NY (first edition: 1967, second edition: 1975, third edition: 1983) (UNCLASSIFIED).

Ward, W. D. (1997). Effects of high-intensity sound. In Encyclopedia of Acoustics, ed. M.J. Crocker, 1497-1507. New York: Wiley.

Weston, D. E. (1960). "Underwater Explosions as Acoustic Sources," *Proc. Phys. Soc*., 76, 233 (UNCLASSIFIED).

Yelverton, J. T. (1981). Underwater Explosion Damage Risk Criteria for Fish, Birds, and Mammals, Manuscript, presented at 102nd Meeting of the Acoustical Society of America, Miami Beach, FL, December, 1982. 32pp.

Yelverton, J. T., D. R. Richmond, E. R. Fletcher, and R. K. Jones (1973). Safe distances from underwater explosions for mammals and birds. Albuquerque, New Mexico, Lovelace Foundation for Medical Education and Research: 66.

This page is intentionally blank.

APPENDIX B

MARINE MAMMALS DEPTH DISTRIBUTIONS

This page is intentionally blank.

MARINE MAMMALS DEPTH DISTRIBUTIONS USED IN ACOUSTIC MODELING

Source: Watwood, S. L., and D. M. Buonantony, 2012. Dive Distribution and Group Size Parameters for Marine Species Occurring in Navy Training and Testing Areas in the North Atlantic and North Pacific Oceans. NUWC-NPT Technical Document12,085. 12 March 2012.

Table B-1. Marine Mammals Depth Distributions Used in Acoustic Modeling

Species	Depth Category (m = meters)	Percentage of Time at Depth
Humpback whale	0–10 m	39.55
	10–20 m	26.51%
	20–30 m	11.66%
	30–40 m	4.25%
	40–50 m	3.04%
	50–60 m	2.47%
	60–70 m	2.14%
	70–80 m	1.66%
	80–90 m	1.97%
	90–100 m	1.55%
	100–110 m	1.39%
	110–120 m	1.31%
	120–130 m	0.92%
	130–140 m	0.72%
	140–150 m	0.20%
	150–160 m	0.23%
	160–170 m	0.15%
	170–180 m	0.09%
Blue whale	0–15 m	43.078%
	15–30 m	29.621%
	30–45 m	9.376%
	45–60 m	2.334%
	60–75 m	2.342%
	75–90 m	2.341%
	90–105 m	2.264%
	105–120 m	2.094%
	120–135 m	1.859%
	135–150 m	1.528%
	150–165 m	1.187%
	165–180 m	0.819%
	180–195 m	0.532%
	195–210 m	0.312%
	210–225 m	0.172%
	225–240 m	0.084%
	240–255 m	0.035%
	255–270 m	0.013%
	270–285 m	0.005%
	285–300 m	0.002%
	300–315 m	0.001%
Fin whale	0–15 m	46.460%

Table B-1. Marine Mammals Depth Distributions Used in Acoustic Modeling, Cont'd

Species	Depth Category (m = meters)	Percentage of Time at Depth
	15–30 m	10.738%
	30–45 m	9.105%
	45–60 m	4.033%
	60–75 m	2.684%
	75–90 m	2.466%
	90–105 m	2.231%
	105–120 m	2.148%
	120–135 m	1.947%
	135–150 m	1.762%
	150–165 m	1.633%
	165–180 m	1.592%
	180–195 m	1.712%
	195–210 m	2.107%
	210–225 m	2.663%
	225–240 m	2.834%
	240–255 m	2.217%
	255–270 m	1.125%
	270–285 m	0.361%
	285–300 m	0.081%
	300–315 m	0.011%
	315–330 m	0.001%
Sei whale and Bryde's whale	0–40 m	84.50%
	40–292 m	15.30%
Minke whale	0–25 m	79.70%
	25–65 m	20.30%
Sperm whale	0–50 m	30.689%
	50–100 m	3.220%
	100–150 m	3.372%
	150–200 m	3.587%
	200–250 m	3.757%
	250–300 m	3.893%
	300–350 m	4.057%
	350–400 m	4.434%
	400–450 m	4.668%
	450–500 m	5.167%
	500- 550 m	4.750%
	550–600 m	4.024%
	600–650 m	3.537%
	650–700 m	3.112%
	700–750 m	2.786%
	750–800 m	2.461%
	800–850 m	2.149%
	850–900 m	1.836%
	900–950 m	1.563%
	950–1000 m	1.316%
	100–1050 m	1.098%
	1050–1100 m	0.892%
	1100–1150 m	0.712%

Table B-1. Marine Mammals Depth Distributions Used in Acoustic Modeling, Cont'd

Species	Depth Category (m = meters)	Percentage of Time at Depth
	1150–1200 m	0.581%
	1200–1250 m	0.472%
	1250–1300 m	0.382%
	1300–1350 m	0.306%
	1350–1400 m	0.248%
	1400–1450 m	0.194%
	1450–1500 m	0.161%
	1500–1550 m	0.128%
	1550–1600 m	0.110%
	1600–1650 m	0.086%
	1650–1700 m	0.069%
	1700–1750 m	0.051%
	1570–1800 m	0.039%
	1800–1850 m	0.028%
	1850–1900 m	0.019%
	1900–1950 m	0.013%
	1950–2000 m	0.009%
	2000–2050 m	0.006%
	2050–2100 m	0.004%
	2100–2150 m	0.003%
	2150–2200 m	0.002%
	2200–2250 m	0.002%
	2250–2300 m	0.002%
	2300–2350 m	0.001%
	2350–2400 m	0.001%
Pygmy sperm whale and Dwarf sperm whale	0–17 m	74.40%
	17–35 m	5.20%
	35–53 m	2.20%
	53–101 m	3.80%
	101–149 m	2.80%
	149–197 m	1.80%
	197–299 m	3.40%
	299–401 m	2.60%
	401–599 m	2.90%
	599–797 m	0.90%
Killer whale	0–5 m	24%
	5–10 m	3.50%
	10–15 m	2.50%
	15–20 m	4.20%
	20–25 m	8%
	25–30 m	12%
	30–35 m	11%
	35–40 m	8.50%
	40–45 m	10.90%
	45–50 m	8.50%
	50–55 m	5%
	55–60 m	1.50%
	60–65 m	0.40%

Table B-1. Marine Mammals Depth Distributions Used in Acoustic Modeling, Cont'd

Species	Depth Category (m = meters)	Percentage of Time at Depth
False killer whale, Pygmy killer whale, and Melon-headed whale	0–1 m	24.7500%
	1–2 m	13.5000%
	2–10 m	16.5000%
	10–50 m	43.5000%
	50–100 m	1.1875%
	100–150 m	0.1375%
	150–600 m	0.4250%
Short-finned pilot whale and Fraser's dolphin	0–17 m	74.40%
	17–35 m	5.20%
	35–53 m	2.20%
	53–101 m	3.80%
	101–149 m	2.80%
	149–197 m	1.80%
	197–299 m	3.40%
	299–401 m	2.60%
	401–599 m	2.90%
	599–797 m	0.90%
Bottlenose dolphin	0–5 m	74.21%
	5–10 m	17.04%
	10–15 m	3.09%
	15–20 m	1.41%
	20–25 m	1.87%
	25–30 m	1.59%
	30–35 m	0.66%
	35–40 m	0.12%
	40–45 m	0.01%
Pantropical spotted dolphin, Striped dolphin, and Spinner dolphin	0–2 m	20.40%
	2–4 m	10.70%
	4–6 m	8.60%
	6–8 m	9.00%
	8–10 m	9.50%
	10–20 m	21.30%
	20–30 m	8.80%
	30–40 m	3.80%
	40–50 m	2.50%
	50–60 m	1.90%
	60–70 m	1.10%
	70–80 m	0.60%
	80–90 m	0.60%
	90–100 m	0.40%
	100–110 m	0.40%
	110–120 m	0.30%
	120–130 m	0.10%
	130–140 m	0.10%
	140–150 m	0.10%
	150–160 m	0.10%
	160–170 m	0.10%
Rough-toothed dolphin	0–10 m	77.99%

Table B-1. Marine Mammals Depth Distributions Used in Acoustic Modeling, Cont'd

Species	Depth Category (m = meters)	Percentage of Time at Depth
	10–25 m	16.24%
	25–50 m	3.81%
	50–75 m	0.93%
	75–100 m	0.29%
	100–150 m	0.11%
	150–200 m	0.01%
	200–300 m	0.01%
Risso's dolphin	0–1 m	24.7500%
	1–2 m	13.5000%
	2–10 m	16.5000%
	10–50 m	43.5000%
	50–100 m	1.1875%
	100–150 m	0.1375%
	150–600 m	0.4250%
Cuvier's beaked whale	0–50 m	49.76%
	50–100 m	6.38%
	100–150 m	5.91%
	150–200 m	5.03%
	200–250 m	3.92%
	250–300 m	2.95%
	300–350 m	2.16%
	350–400 m	1.63%
	400–450 m	1.41%
	450–500 m	1.36%
	500- 550 m	1.35%
	550–600 m	1.28%
	600–650 m	1.35%
	650–700 m	1.41%
	700–750 m	1.43%
	750–800 m	1.33%
	800–850 m	1.29%
	850–900 m	1.28%
	900–950 m	1.25%
	950–1000 m	1.13%
	100–1050 m	1.07%
	1050–1100 m	0.93%
	1100–1150 m	0.80%
	1150–1200 m	0.74%
	1200–1250 m	0.61%
	1250–1300 m	0.49%
	1300–1350 m	0.41%
	1350–1400 m	0.29%
	1400–1450 m	0.21%
	1450–1500 m	0.22%
	1500–1550 m	0.18%
	1550–1600 m	0.15%
	1600–1650 m	0.09%
	1650–1700 m	0.07%

Table B-1. Marine Mammals Depth Distributions Used in Acoustic Modeling, Cont'd

Species	Depth Category (m = meters)	Percentage of Time at Depth
	1700–1750 m	0.05%
	1570–1800 m	0.03%
	1800–1850 m	0.01%
	1850–1900 m	0.01%
Blaineville's beaked whale and Longman's beaked whale	0–20 m	43.447%
	20–40 m	8.743%
	40–60 m	7.116%
	60–80 m	5.665%
	80–100 m	4.134%
	100–120 m	2.793%
	120–140 m	1.740%
	140–160 m	1.127%
	160–180 m	0.772%
	180–200 m	0.597%
	200–220 m	0.500%
	220–240 m	0.470%
	240–260 m	0.460%
	260–280 m	0.455%
	280–300 m	0.454%
	300–320 m	0.454%
	320–340 m	0.456%
	340–360 m	0.458%
	360–380 m	0.458%
	380–400 m	0.460%
	400–420 m	0.461%
	420–440 m	0.465%
	440–460 m	0.478%
	460–480 m	0.492%
	480–500 m	0.505%
	500–520 m	0.520%
	520–540 m	0.528%
	540–560 m	0.553%
	560–580 m	0.576%
	580–600 m	0.589%
	600–620 m	0.605%
	620–640 m	0.642%
	640–660 m	0.697%
	660–680 m	0.715%
	680–700 m	0.708%
	700–720 m	0.694%
	720–740 m	0.727%
	740–760 m	0.739%
	760–780 m	0.741%
	780–800 m	0.758%
	800–820 m	0.781%
	820–840 m	0.775%
	840–860 m	0.694%
	860–880 m	0.624%

Table B-1. Marine Mammals Depth Distributions Used in Acoustic Modeling, Cont'd

Species	Depth Category (m = meters)	Percentage of Time at Depth
	880–900 m	0.601%
	900–920 m	0.566%
	920–940 m	0.512%
	940–960 m	0.444%
	960–980 m	0.384%
	980–1000 m	0.330%
	1000–1020 m	0.285%
	1020–1040 m	0.228%
	1040–1060 m	0.182%
	1060–1080 m	0.146%
	1080–1100 m	0.110%
	1100–1120 m	0.078%
	1120–1140 m	0.057%
	1140–1160 m	0.048%
	1160–1180 m	0.050%
	1180–1200 m	0.045%
	1200–1220 m	0.030%
	1220–1240 m	0.015%
	1240–1260 m	0.004%
	1260–1280 m	0.004%
	1280–1300 m	0.001%
	1300–1320 m	0.001%
	1320–1340 m	0.001%
	1340–1360 m	0.001%
Hawaiian monk seal	0–4 m	33.00%
	4–20 m	34.70%
	20–40 m	13.20%
	40–60 m	5.50%
	60–80 m	3.60%
	70–100 m	2.10%
	100–120 m	2.50%
	120–140 m	2.00%
	140–160 m	0.80%
	160–180 m	0.70%
	180–200 m	0.30%
	200–250 m	0.40%
	250–350 m	0.90%
	350–500 m	0.60%

This page is intentionally blank.

This page is intentionally blank.

APPENDIX B

AIR QUALITY EMISSIONS CALCULATIONS

This page is intentionally blank.

B.1 AIR QUALITY EXAMPLE CALCULATIONS

This appendix discusses emissions factor development and calculations, including assumptions employed in the analyses presented in the air quality section of Chapter 3 (Section 3.1).

B.1.1 Air Activities Emissions

Aircraft activities of concern are those involving fixed- and rotary-winged aircraft that occur from ground level up to 3,000 feet (914 meters) above ground level. The 3,000-foot (914-meter) above ground level ceiling was assumed to be the atmospheric mixing height above which any pollutant generated would not contribute to increased pollutant concentrations at ground level (known as the “mixing zone”). All aircraft pollutant emissions generated at heights above 3,000 feet (914 meters) above ground level are excluded from this analysis. The pollutant emission rate is a function of the engine’s operating mode, the fuel flow rate, and the engine’s overall efficiency. Emissions for one complete flight for a particular aircraft are calculated by knowing the specific engine pollutant emissions factors for each mode of operation.

For this EA, fixed-wing aircraft emissions factors were obtained from the Air Conformity Applicability Model (ACAM), version 5.0.2.

Rotary-wing aircraft emissions factors were obtained from the Navy Aircraft Environmental Support Office (i.e., AESO). The following memoranda were used in aircraft emissions calculations:

- AESO Memorandum Report No. 9953 Revision C, *Aircraft Emission Estimates: H-60 Mission Operations Using JP-5.* Fleet Readiness Center Southwest January 2014.
- AESO Memorandum Report No. 2012-01D Revision C, *Sulfur Dioxide Emission Index Using JP-5 and JP-8 Fuel.* Fleet Readiness Center Southwest December 2014.
- AESO Report 2013-04, Revision A May 2013. *$PM_{2.5}$ to PM_{10} Ratio for Aircraft Emitted Particles.* Fleet Readiness Center Southwest January 2014.

Emissions factors vary depending on engine power mode, time in each mode, and fuel flow. Using these data, as well as information on activity levels (i.e., hours of operation), pollutant emissions for each aircraft and activity were calculated by applying the equation below.

Emissions = TIM × FF × EF × ENG × CF,
where:

> *Emissions = aircraft emissions (pounds per activity) (for EF in pounds/1,000 gallons fuel)*
> *TIM = time-in-mode at a specified power setting (hours/activity).*
> *FF = fuel flow at a specified power setting (gallons/hour/engine)*
> *EF = emissions factor for specific engine type and power setting (pounds/1,000 gallons of fuel used)*
> *ENG = number of engines on aircraft*
> *CF = conversion factor (0.001)*

As the equation indicates, emissions were estimated by first calculating total fuel used in each of the different modes with the appropriate emission factor.

The following is a list of emissions factors used in the EA:

	Power Setting	Fuel Flow	VOCs	SO_x	NO_x	CO	PM_{10}	$PM_{2.5}$	CO_2e
B-1B	Intermediate	6,557	0.04	1.06	13.15	0.85	1.35	0.72	3,252.46
F-15E	Intermediate	5,838	0.35	1.06	17.54	0.15	2.06	1.85	3,252.46
F-16D	Intermediate	6,939	0.05	1.06	17.82	1.53	0.58	0.41	3,252.46

	Power Setting	Fuel Flow	VOCs	SO_x	NO_x	CO	PM_{10}	$PM_{2.5}$	CO_2e
F-22A	Intermediate	10,110	0.03	1.06	12.4	2.14	1.4	1.09	3,252.46
F-35A	Intermediate	16,068	0	1.06	18.5	0.6	1.17	1.01	3,252.46
KC-135T	Intermediate	5,650	0.03	1.06	11.04	2.32	0.65	0.36	3,252.46
P-3C	Intermediate	1,408.92	0.04	1.06	10.3	1.07	0.17	0.15	3,252.46
H-60	Cruise	1,199.7	0.069	0	7.68	7.5	5.04	5.04	3,864.67
C-26C	Intermediate	409	0.17	1.06	11.86	0.98	1.47	1.32	3,252.46

CO = carbon monoxide; CO_2e = equivalent emissions of carbon dioxide; NO_x = nitrogen oxides; PM_{10} and $PM_{2.5}$ = particulate matter with a diameter of less than or equal to 10 microns and 2.5 microns, respectively; SO_x = sulfur oxides; VOC = volatile organic compound

B.1.3 Ordnance and Munitions Emissions

Available emissions factors (AP-42, Compilation of Air Pollutant Emission Factors) were utilized (USEPA, 2008). These factors were then multiplied by the net weight of the explosive (or a conversion factor for pounds per item) and the number of times that the munition was used during a designated time frame. This calculation provided annual pounds per year of emissions, which were converted to tons per year for comparison purposes.

Emissions = EXP/YR × EF × Net Wt × CF,
where:

Emissions = ordnance emissions (pounds per year)
EXP/YR = explosives, propellants, and pyrotechnics used per year
EF = emissions factor
Net Wt = net weight of explosive
CF = conversion factor for pounds to tons

B.2 REFERENCES

U.S. Environmental Protection Agency (USEPA), 2008. AP-42, Fifth Edition, Volume I hHapter 15: Ordnance Detonation. Accessed online at http://www.epa.gov/ttn/chief/ap42/ch15/index.html on August 20, 2015.

U.S. Environmental Protection Agency (USEPA), 2010. Current Methodologies in Preparing Mobile Source Port-Related Emission Inventories. Prepared by ICF International, April 2009.