BIOLOGICAL ASSESSMENT FOR FLIGHT EXPERIMENT-2

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LIST OF ACRONYMS AND ABBREVIATIONS

Acronym or Abbreviation	Full Phrase
°C	degrees Celsius
°F	degrees Fahrenheit
μPa	micropascal
ARSTRAT	Army Forces Strategic Command
BA	Biological Assessment
BO	Biological Opinion
BOA	Broad Ocean Area
CFR	Code of Federal Regulations
CITES	Convention on International Trade in Endangered Species
cm	centimeter
CO_2	carbon dioxide
CV	coefficient of variation
dB	decibels
DEP	Document of Environmental Protection
DoD	Department of Defense
DPS	Distinct Population Segment
EA	Environmental Assessment
EEZ	Exclusive Economic Zone
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
ESA	Endangered Species Act
FAO	Food and Agriculture Organization of the United Nations
FE-1	Flight Experiment-1
FE-2	Flight Experiment-2
ft	feet
ft^2	square feet
ft^3	cubic feet
FR	Federal Register
FTS	Flight Termination System
HCl	hydrochloric acid
Hz	hertz
in	inch
KEEP	Kwajalein Environmental Emergency Management Plan
kg	kilogram
kHz	kilohertz
km	kilometer
km^2	square kilometer
KTF	Kauai Test Facility
L	liter
lb	pound(s)
LCU	Landing Craft Utility
LIDSS	Lawrence Livermore National Laboratory Independent Diagnostic Scoring System
m	meter
m^2	square meter

Acronym or Abbreviation	Full Phrase
m^3	cubic meters
MATSS	Mobile At-Sea Sensor
mg	milligram
mi	mile
mi^2	square mile
MIMRA	Marshall Islands Marine Resource Authority
MMIII	Minuteman III
MMPA	Marine Mammal Protection Act
ms	millisecond
nm	nautical mile
NASA	National Aeronautics and Space Administration
NMFS	National Marine Fisheries Service
NWHI	Northwestern Hawaiian Islands
OEIS	Overseas Environmental Impact Statement
PMRF	Pacific Missile Range Facility
PNA	Parties to the Nauru Agreement
PTS	Permanent Threshold Shift
re	referenced to
RMI	Republic of the Marshall Islands
RMS	Root Mean Squared
ROV	Remotely Operated Vehicle
RTS	Ronald Reagan Ballistic Missile Defense Test Site
SEL	Sound Exposure Level
SPL	Sound Pressure Level
SSP	Strategic Systems Program
STARS	Strategic Target System
TTS	Temporary Threshold Shift
UES	USAKA Environmental Standards
US	United States
USAFGSC	United States Air Force Global Strike Command
USAG-KA	United States Army Garrison – Kwajalein Atoll
USAKA	United States Army Kwajalein Atoll
USASMDC	United States Army Space and Missile Defense Command
USC	United States Code
USFWS	United States Fish and Wildlife Service
W	tungsten

1.0 EXECUTIVE SUMMARY

The proposed Flight Experiment-2 (FE-2) is sponsored by the Office of the Under Secretary of Defense for Research and Engineering, which has designated the United States Department of the Navy (US Navy) Strategic Systems Programs (SSP) as the lead agency and action proponent for the Proposed Action. The US Navy, along with the Department of Energy and the National Aeronautics and Space Administration (NASA) as Cooperating Agencies, and with the US Army Space and Missile Defense Command/Army Forces Strategic Command (USASMDC/ARSTRAT) as a Participating Agency, have prepared this Biological Assessment (BA) to determine the extent to which a single experimental flight test of the FE-2 and associated activities may affect species requiring consultation.

The US Navy SSP proposes to conduct one experimental flight test to take place within the first half of fiscal year 2020. The purpose of the Proposed FE-2 Action is to collect data on a developmental payload to enable testing, modeling, and simulation of the developmental payload system and mature the technologies necessary to ultimately establish an operational strike capability. FE-2 is the next incremental step in the developmental process after Flight Experiment-1 (FE-1). FE-1 was a very similar test flight conducted in 2017. FE-2 would continue to develop, integrate, and flight test a payload system to demonstrate the maturity of key technologies. These technologies include precision navigation, guidance and control, and other capability enhancements. FE-2 would help further establish aerodynamic, thermal, and structural limits of the payload system. Data collected would be utilized to improve the models that predict the performance of the payload system.

The Proposed Action involves conducting an FE-2 flight test from the Pacific Missile Range Facility (PMRF) in Hawai`i to the Ronald Reagan Ballistic Missile Defense Test Site (Reagan Test Site [RTS]) at the US Army Kwajalein Atoll (USAKA) in the Republic of the Marshall Islands (RMI). After launch from PMRF, the developmental payload would travel across a broad ocean area (BOA) of the Pacific Ocean and impact at Illeginni Islet in Kwajalein Atoll.

The Compact of Free Association between the RMI and the United States (48 United States Code [USC], Section [§] 1921) requires all US Government activities at USAKA and all Department of Defense (DoD) and RTS activities in the RMI to conform to specific compliance requirements, coordination procedures, and environmental standards identified in the *Environmental Standards and Procedures for USAKA Activities in the RMI*, also known as the USAKA Environmental Standards (UES; USASMDC/ARSTRAT 2018). As specified in Section 2-2 of the UES, these standards also apply to all activities occurring in the territorial waters of the RMI. The UES requires that a BA must be prepared when a proposed activity may affect certain species protected by UES consultation procedures. Because the Action Area includes zones outside of RMI territorial waters to which the UES does not apply, consultations under the terms of the US Endangered Species Act (ESA) and compliance with the US Marine Mammal Protection Act (MMPA) are also required.

Section 2 of this BA describes the purpose and need for the Proposed Action. Section 2 also includes information about the regulatory setting of this BA.

Section 3 defines the Action Area for the Proposed Action and provides a detailed description of the Proposed Action. Section 3 also outlines the environmental stressors associated with the Proposed Action as well as discretionary mitigation measures proposed to minimize the impacts of the FE-2 flight test.

Section 4 of this BA introduces the species requiring consultation that occur or have the potential to occur in the Action Area and may be affected by the Proposed Action including a description of each species, the known distribution of the species, the population of the species in the Action Area, and status and threats to each species. There are 25 cetacean, 1 phocid, 1 bird, 5 sea turtle, 7 fish, 22 coral, and 5 mollusk species that have the potential to occur within the Action Area and may be affected by the Proposed Action. There is no critical habitat for any consultation species located within the Action Area.

Section 5 evaluates the effects of the Proposed Action. The potential stressors that would be associated with the Proposed Action are described, including exposure to elevated sound pressure levels, direct contact with FE-2 components, vessel strike, exposure to hazardous chemicals, and disturbance from human activity and equipment operation. The direct and indirect effects of these stressors on consultation species are analyzed and discussed for all portions of the Action Area. For each stressor and portion of the Action Area, an effect determination is presented for each species or group of species. Under the ESA, actions may have no effects, have an effect that is beneficial, have an effect that is unlikely to be adverse, or have an effect that is likely to be adverse as further defined in Section 5.

Section 6 describes the potential cumulative effects of future non-federal activities that are reasonably certain to occur in the Action Area and examines the cumulative effects of the activities on consultation organisms.

Section 7 summarizes the effects of the Action on consultation species. This section includes conclusions for effect determinations as well as population level context for effects on consultation species.

Based on analyses of all of the potential stressors in the Action Area, a no effect determination was concluded for 24 cetacean species, Hawaiian monk seals, Newell's shearwaters, 5 sea turtle species, 2 species of sharks, Oceanic giant manta rays, Pacific bluefin tuna, and larval fish, corals, and mollusks in the BOA of the Action Area (Table 1-1).

A "may affect but is not likely to adversely affect" determination was concluded for 11 cetacean species, green turtles, hawksbill turtles, reef manta rays, Oceanic giant manta rays, 15 coral species, 2 mollusk species, and larval fish, corals, and mollusks near Illeginni Islet (Table 1-1). It is possible that a relatively small and undeterminable number of fish, coral, or mollusk larvae will be adversely affected within some portions of the Action Area. However, because the affected areas are trivially small relative to the distribution of these invertebrates and because the number of larvae potentially affected is likely to be trivially small relative to their population sizes, these adverse effects are considered insignificant and discountable.

A "may affect and is likely to adversely affect" determination was concluded for one fish species (the humphead wrasse), seven coral species (*Acropora microclados, A. polystoma, Cyphastrea agassizi, Heliopora coerulea, Pavona venosa, Pocillopora meandrina,* and *Turbinaria reniformis*) and three mollusk species (*Hippopus hippopus, Tectus niloticus,* and *Tridacna squamosa*; Table 1-1). Although marine habitats will not be intentionally targeted, these conclusions are based on analysis of a worst-case scenario involving a shoreline payload impact where debris and shockwaves could enter the marine environment. Analyses provide evidence that a maximum of 8 adult or 100 juvenile humphead wrasse, 5,692 coral colonies, and 79 individual mollusks might be affected by FE-2 activities (detailed in Section 5.1.2).

Table 1-1
Effect Determinations for Species Requiring Consultation‡ in the Action Area
("-"= not known to be present in effect area, x = no effect, ○=may affect but not likely to adversely affect, ●=may affect and likely to adversely affect).

Scientific Name	Common Name	BOA					Vicinity of Illeginni Islet				
		Elevated Sound	Direct Contact	Vessel Strike	Hazard. Chem.	Human Disturb.	Elevated Sound	Direct Contact	Vessel Strike	Hazard. Chem.	Human Disturb.
Cetaceans											
Balaenoptera acutorostrata	Minke whale	x	x	x	x	x	x	-	○	-	○
B. borealis	Sei whale	x	x	x	x	x	-	-	-	-	-
B. edeni	Bryde's whale	x	x	x	x	x	x	-	○	-	○
B. musculus	Blue whale	x	x	x	x	x	-	-	-	-	-
B. physalus	Fin whale	x	x	x	x	x	-	-	-	-	-
Delphinus delphis	Short-beaked common dolphin	-	-	-	-	-	x	-	○	-	○
Feresa attenuata	Pygmy killer whale	x	x	x	x	x	-	-	-	-	-
Globicephala macrorhynchus	Short-finned pilot whale	x	x	x	x	x	x	-	○	-	○
Grampus griseus	Risso's dolphin	x	x	x	x	x	-	-	-	-	-
Indopacetus pacificus	Longman's beaked whale	x	x	x	x	x	-	-	-	-	-
Kogia breviceps	Pygmy sperm whale	x	x	x	x	x	-	-	-	-	-
K. sima	Dwarf sperm whale	x	x	x	x	x	-	-	-	-	-
Lagenodelphis hosei	Fraser's dolphin	x	x	x	x	x	-	-	-	-	-
Megaptera novaeangliae	Humpback whale	x	x	x	x	x	-	-	-	-	-
Mesoplodon densirostris	Blainville's beaked whale	x	x	x	x	x	-	-	-	-	-
Orcinus orca	Killer whale	x	x	x	x	x	x	-	○	-	○
Peponocephala electra	Melon-headed whale	x	x	x	x	x	x	-	○	-	○
Physeter macrocephalus	Sperm whale	x	x	x	x	x	x	-	○	-	○
Pseudorca crassidens	False killer whale	x	x	x	x	x	-	-	-	-	-
Stenella attenuata	Pantropical spotted dolphin	x	x	x	x	x	x	-	○	-	○
S. coeruleoalba	Striped dolphin	x	x	x	x	x	x	-	○	-	○
S. longirostris	Spinner dolphin	x	x	x	x	x	x	-	○	-	○
Steno bredanensis	Rough-toothed dolphin	x	x	x	x	x	-	-	-	-	-
Tursiops truncatus	Bottlenose dolphin	x	x	x	x	x	x	-	○	-	○
Ziphius cavirostris	Cuvier's beaked whale	x	x	x	x	x	-	-	-	-	-
Phocids											
Neomonachus schauinslandi	Hawaiian monk seal	x	x	x	x	x	-	-	-	-	-
Birds											
Puffinus auricularis newelli	Newell's shearwater	x	x	x	x	x	-	-	-	-	-

Scientific Name	Common Name	BOA					Vicinity of Illeginni Islet				
		Elevated Sound	Direct Contact	Vessel Strike	Hazard. Chem.	Human Disturb.	Elevated Sound	Direct Contact	Vessel Strike	Hazard. Chem.	Human Disturb.
Sea Turtles											
Caretta caretta	Loggerhead turtle	x	x	x	x	x	-	-	-	-	-
Chelonia mydas	Green turtle	x	x	x	x	x	○	○	○	○	○
Dermochelys coriacea	Leatherback turtle	x	x	x	x	x	-	-	-	-	-
Eretmochelys imbricata	Hawksbill turtle	x	x	x	x	x	○	○	○	○	○
Lepidochelys olivacea	Olive ridley turtle	x	x	x	x	x	-	-	-	-	-
Fish (non-larval)											
Alopias superciliosus	Bigeye thresher shark	x	x	x	x	x	-	-	-	-	-
Carcharhinus longimanus	Oceanic whitetip shark	x	x	x	x	x	-	-	-	-	-
Cheilinus undulatus	Humphead wrasse	-	-	-	-	-	○	●	○	○	●
Manta alfredi	Reef manta ray	-	-	-	-	-	○	○	○	○	○
M. birostris	Oceanic giant manta ray	x	x	x	x	x	○	○	○	○	○
Sphyrna lewini	Scalloped hammerhead	-	-	-	-	-	○	-	○	-	○
Thunnus orientalis	Pacific bluefin tuna	x	x	x	x	x	-	-	-	-	-
Corals (non-larval)											
Acanthastrea brevis		-	-	-	-	-	x	○	○	○	○
Acropora aculeus		-	-	-	-	-	x	○	○	○	○
A. aspera		-	-	-	-	-	x	○	○	○	○
A. dendrum		-	-	-	-	-	x	○	○	○	○
A. listeri		-	-	-	-	-	x	○	○	○	○
A. microclados		-	-	-	-	-	x	●	○	○	●
A. polystoma		-	-	-	-	-	x	●	○	○	●
A. speciosa		-	-	-	-	-	x	○	○	○	○
A. tenella		-	-	-	-	-	x	○	○	○	○
A. vaughani		-	-	-	-	-	x	○	○	○	○
Alveopora verrilliana		-	-	-	-	-	x	○	○	○	○
Cyphastrea agassizi		-	-	-	-	-	x	●	○	○	●
Heliopora coerulea		-	-	-	-	-	x	●	○	○	●
Leptoseris incrustans		-	-	-	-	-	x	○	○	○	○
Montipora caliculata		-	-	-	-	-	x	○	○	○	○
Pavona cactus		-	-	-	-	-	x	○	○	○	○
P. decussata		-	-	-	-	-	x	○	○	○	○
P. venosa		-	-	-	-	-	x	●	○	○	●
Pocillopora meandrina		-	-	-	-	-	x	●	○	○	●
Turbinaria mesenterina		-	-	-	-	-	x	○	○	○	○
T. reniformis		-	-	-	-	-	x	●	○	○	●
T. stellulata		-	-	-	-	-	x	○	○	○	○

Scientific Name	Common Name	BOA					Vicinity of Illeginni Islet				
		Elevated Sound	Direct Contact	Vessel Strike	Hazard. Chem.	Human Disturb.	Elevated Sound	Direct Contact	Vessel Strike	Hazard. Chem.	Human Disturb.
Mollusks (non-larval)											
Hippopus hippopus	Giant clam	-	-	-	-	-	x	●	○	○	●
Pinctada margaritifera	Black-lipped pearl oyster	-	-	-	-	-	x	○	○	○	○
Tectus niloticus	Top shell snail	-	-	-	-	-	x	●	○	○	●
Tridacna gigas	Giant clam	-	-	-	-	-	x	○	○	○	○
T. squamosa	Giant clam	-	-	-	-	-	x	●	○	○	●
Larval Fish, Coral, and Mollusks		x	x	x	x	x	x	○	○	○	○

2.0 INTRODUCTION

2.1 Purpose and Objectives

The purpose of this Biological Assessment (BA) is to address the potential effects of the United States (US) Department of the Navy (Navy) Strategic Systems Programs (SSP) proposed single flight test of the Flight Experiment-2 (FE-2) on species listed as endangered or threatened under the Endangered Species Act (ESA) and on species protected under the standards identified in the USAKA Environmental Standards (UES) or their designated critical habitat. The US Navy, along with the Department of Energy and the National Aeronautics and Space Administration (NASA) as Cooperating Agencies, and with the US Army Space and Missile Defense Command/Army Forces Strategic Command (USASMDC/ARSTRAT) as a Participating Agency, have prepared this BA. The US Navy intends to carry out the action described below, in accordance with Sections 5013 and 5062 of Title 10, United States Code (USC).

The Proposed Action involves conducting an FE-2 flight test to collect data on a developmental payload. This FE-2 program involves a test flight of the Navy's developmental payload from the Pacific Missile Range Facility (PMRF) in Hawai`i to the Ronald Reagan Ballistic Missile Defense Test Site (Reagan Test Site [RTS]) at US Army Kwajalein Atoll (USAKA) in the Republic of the Marshall Islands (RMI). It has the potential to impact several ESA-listed and UES-protected species that occur in the Action Area including 25 cetacean, 1 pinniped, 5 sea turtle, 7 fish, 5 mollusk, and 22 coral species. There is no designated critical habitat for any of these species in the Action Area.

This BA addresses the Proposed Action in compliance with Section 7 of the ESA. Section 7 assures that, through consultation with the National Marine Fisheries Service (NMFS) and US Fish and Wildlife Service (USFWS), federal actions are not likely to jeopardize the continued existence of any threatened, endangered, or proposed species, or result in the destruction or adverse modification of critical habitat.

The Proposed Action, FE-2, is needed to enable testing, modeling, and simulation of a developmental payload system and mature the technologies necessary to ultimately establish an operational strike capability. A range of possible flight experiment concepts is being studied as a way to inform potential future strike capability determinations. The purpose of FE-2 is to continue to collect data on a developmental payload by testing one such flight experiment concept.

FE-2 is the next incremental step in the developmental process after Flight Experiment-1 (FE-1). FE-1 was a very similar test flight conducted in 2017 from PMRF in Hawai`i to RTS in the RMI. FE-2 would continue to develop, integrate, and flight test a payload system to demonstrate the maturity of key technologies. These technologies include precision navigation, guidance and control, and other capability enhancements. FE-2 would help further establish aerodynamic, thermal, and structural limits of the payload system. Data collected would be utilized to improve the models that predict the performance of the payload system. The Proposed Action would also provide an opportunity to observe the FE-2 missile and payload system from launch-to-impact and record all data transmitted throughout the flight path.

2.2 Regulatory Setting

USAKA Environmental Standards. The Compact of Free Association between the RMI and the US (48 USC Section [§] 1921) requires all US Government activities at USAKA and all DoD and RTS activities in the RMI to conform to specific compliance requirements, coordination procedures, and environmental standards identified in the *Environmental Standards and Procedures for USAKA Activities in the RMI*, also known as the USAKA Environmental Standards (UES; USASMDC/ARSTRAT 2018). As specified in Section 2-2 of the UES, these standards also apply to all activities occurring in the territorial waters of the RMI. The proposed Navy payload test, which could affect Illeginni Islet, the deep-water region southwest of Illeginni Islet, or the deep ocean waters northeast of Kwajalein Atoll, must comply with the UES (USASMDC/ARSTRAT 2018).

Section 3-4 of the UES contains the standards for managing endangered species and wildlife resources. The standards in this section were derived primarily from 50 Code of Federal Regulations (CFR), Sections (§§) 17, 23, 402, 424, and 450-452, which include provisions of the ESA (16 USC §§ 1531-1544) and other regulations applicable to biological resources. Other US statutes embodied in these standards are the Fish and Wildlife Coordination Act (16 USC §§ 661-666), the Migratory Bird Treaty Act (16 USC §§ 703-712), and the Marine Mammal Protection Act (MMPA; 16 USC §§ 1361-1389, 1401-1407, 1538, and 4107). The UES also requires consultation for potential effects on certain species protected by laws of the RMI. The Marshall Islands Marine Resources Authority manages marine resources in the RMI.

The UES contains a requirement that a BA must be prepared when a proposed activity may affect a species requiring consultation. For the purposes of this BA, a species requiring consultation is defined as any species listed in the UES Appendix 3-4A (USASMDC/ARSTRAT 2018), which also includes any candidate or proposed ESA species. The BA must contain an analysis that is sufficient to allow the appropriate regulatory agency to prepare a biological opinion (BO). According to Section 3-4.5.3(g) of the UES, if NMFS or USFWS prepares an adverse opinion or a no adverse opinion with an incidental take statement, an approved Document of Environmental Protection (DEP) must be prepared before proceeding with the proposed activity.

Endangered Species Act. The purpose of the ESA is to conserve the ecosystems upon which threatened and endangered species depend and to conserve and recover listed species. Section 7 of the ESA requires action proponents to consult with the USFWS or National Oceanic and Atmospheric Administration (NOAA) Fisheries to ensure that their actions are not likely to jeopardize the continued existence of federally listed threatened and endangered species or result in the destruction or adverse modification of designated critical habitat (16 USC §§ 1531-1544). For all ESA listed species, the ESA defines “harm” as an act which kills or injures wildlife including significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering (16 USC §§ 1531-1544). The ESA defines harassment as an intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to breeding, feeding, or sheltering.

Marine Mammal Protection Act. All marine mammals are protected under the provisions of the MMPA (16 USC §1361 et seq.). The MMPA prohibits any person or vessel from “taking” marine mammals in the United States or the high seas without authorization. As defined by the MMPA, level A harassment of cetaceans is any act that has the potential to injure a marine mammal or marine mammal stock in the wild. Level B harassment is defined as any act that has the potential to disturb a marine mammal or marine mammal stock in the wild by causing behavioral pattern disruptions, including but not limited to migration, breathing, nursing, breeding, feeding, or sheltering. Under the MMPA, marine mammal stocks can be listed as depleted. The term depleted is defined by the MMPA as any case in which a species or population stock is determined to be below its optimum sustainable population.

3.0 DESCRIPTION OF THE ACTION AREA & PROPOSED ACTION

The Action Area is discussed as it relates to analyses in this BA based on a detailed description of the Proposed Action, as well as descriptions of the regulatory setting, consultation history, environmental stressors, and mitigation measures that are relevant to the Proposed Action. This BA addresses FE-2 effects on biological resources within an Action Area that includes only the post-launch flight path, booster drop zones, and the terminal end of the flight. Potential effects of the Proposed Action pre-launch and launch activities at PMRF have been analyzed separately in the *Hawai`i Range Complex Environmental Impact Statement/Overseas Environmental Impact Statement* (EIS/OEIS; US Navy 2008). The Proposed Action also includes pre-flight preparations in the broad ocean area (BOA) and at USAKA, monitoring throughout the flight, and post-impact terminal end operations in the vicinity of USAKA.

3.1 Description of the Action Area

The Action Area for this BA is as follows:

- The over-ocean flight corridor in the BOA (Figure 3-1);
- Spent rocket motor drop zones in the BOA (Figure 3-2); and
- The terminal end of payload flight, which consists of impact at Illeginni Islet (Figure 3-3, Figure 3-4).

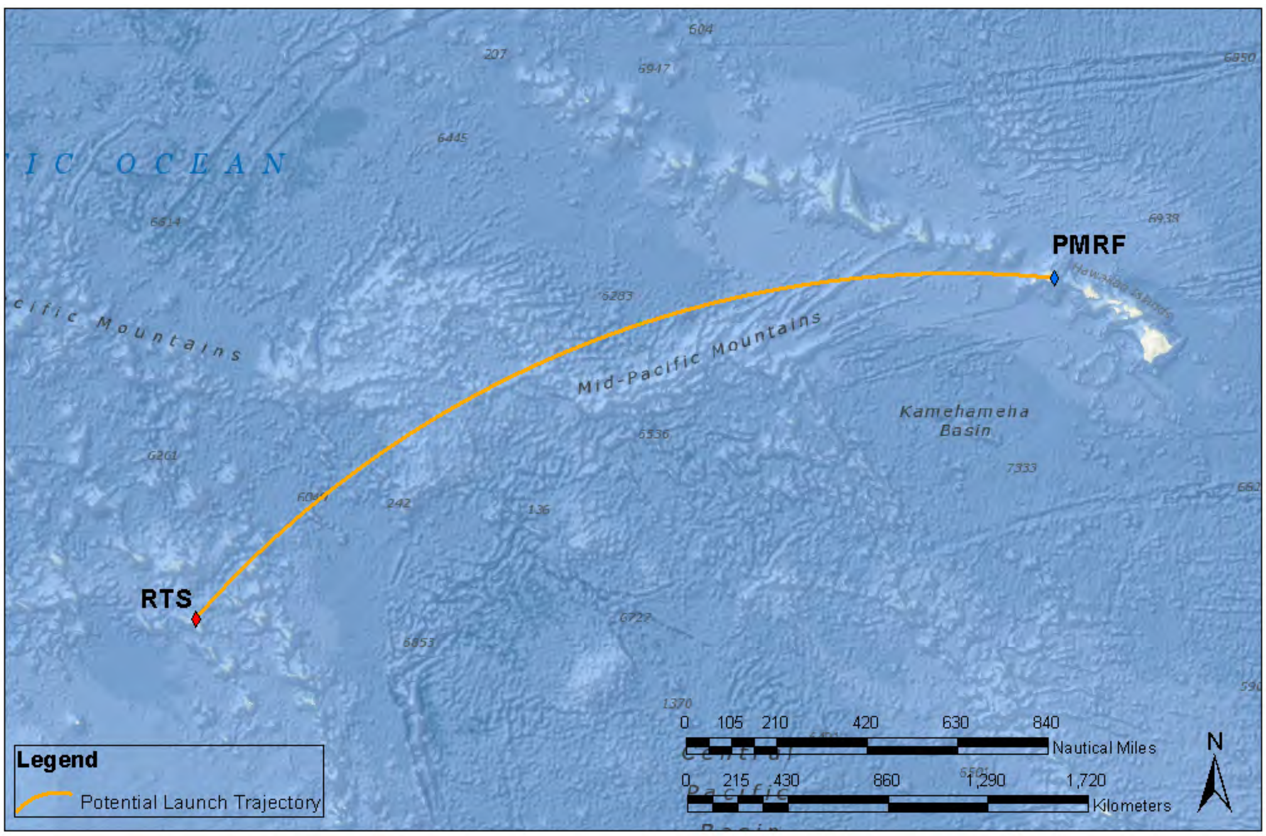

Figure 3-1. Flight Experiment-2 (FE-2) Representative Flight Path.

Spent Rocket Motor Drop Zones. The US Navy SSP FE-2 launch vehicle consists of a 3-stage Strategic Target System (STARS) booster system and the experiment payload (see Section 3.2). The three STARS rocket booster motors will splash down in the Pacific Ocean following burnout and separation (Figure 3-2). The first-stage motor would burn out and separate from the second stage. Further into flight, the second-stage and third-stage motors would also burn out and separate. The fairing that connects the payload to the third stage will also separate. Jettison of the fairing and payload separation would occur inside the atmosphere. Splashdown of all three spent motor stages and the payload fairing would occur at different points in the open ocean between 65 and 2,800 kilometers (km; 35 and 1,500 nautical miles [nm]) from the launch pad. Figure 3-2 depicts the rocket motor drop zones in the over-ocean flight corridor for the launch from Kauai Test Facility (KTF) towards Kwajalein Atoll.

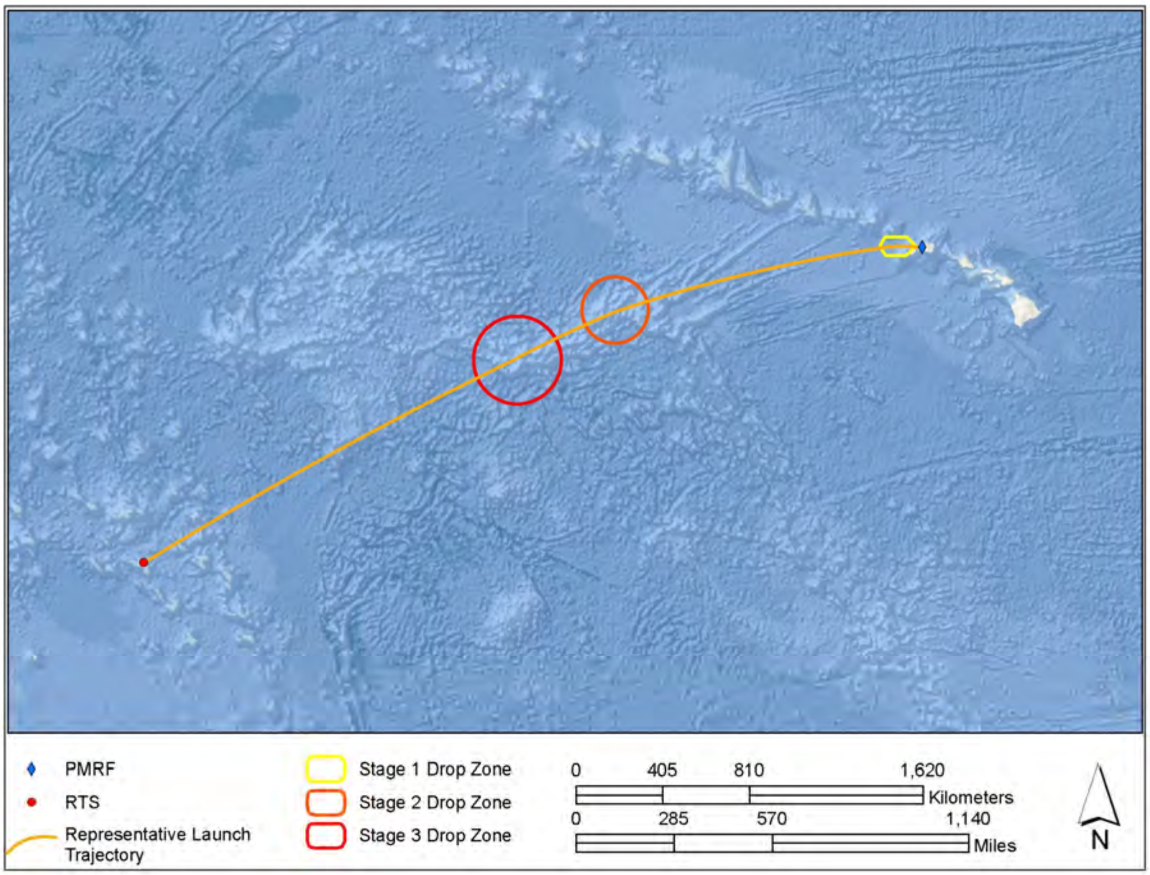

Figure 3-2. Representative Drop Zones for Spent Motor Stages and Nose Fairing Assembly.

Terminal End. The terminal end of the payload flight would be in the vicinity of USAKA in the RMI. The preferred alternative is a land impact on Illeginni Islet (Figure 3-3 and Figure 3-4). This zone is approximately 290 meters (m; 950 feet [ft]) by 137 m (450 ft) on the non-forested, northwest end of the islet. A reef or shallow water impact is not part of the Proposed Action, would be unintentional, and is unlikely to occur.

3.2 Description of the Proposed Action

The Proposed Action analyzed in this BA consists of pre-flight preparations in the BOA and at USAKA, the FE-2 flight test across the BOA, payload impact, and post-flight impact data collection, debris recovery, and clean-up operations at USAKA. The Proposed Action flight test would occur in

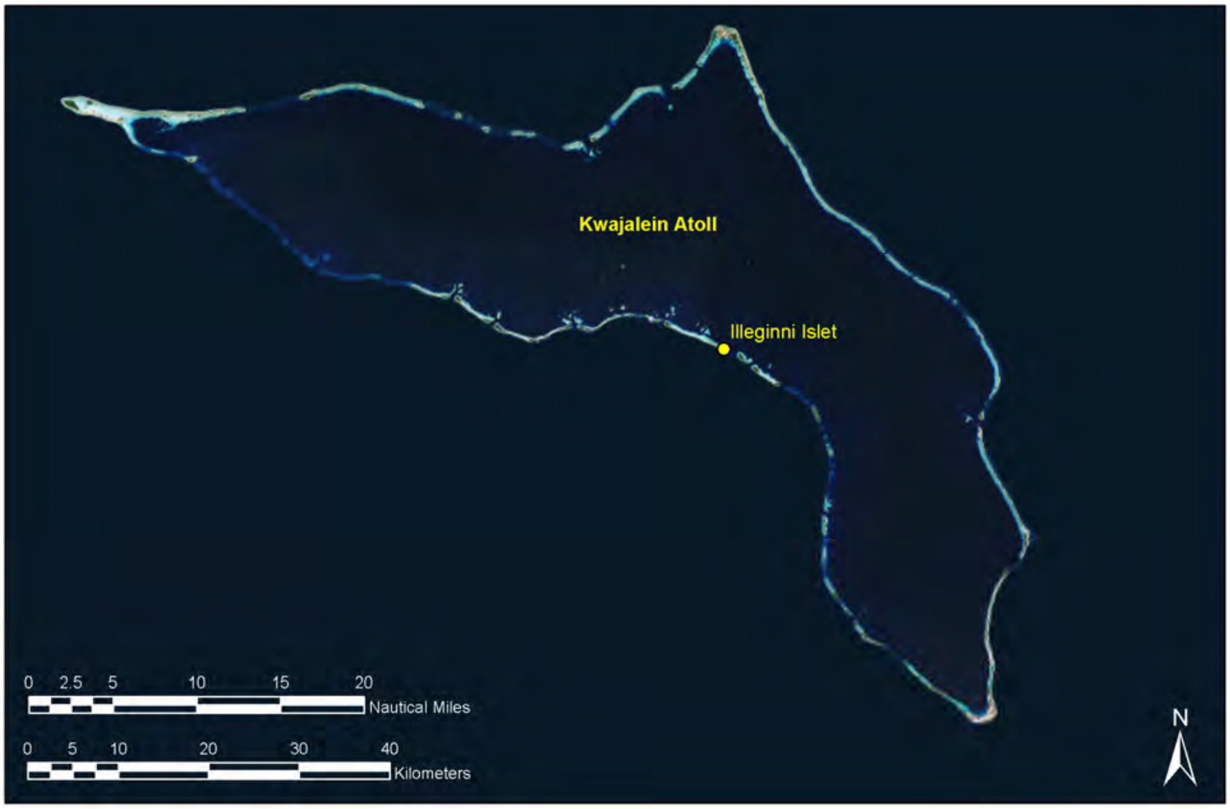

Figure 3-3. Location of Illeginni Islet, Kwajalein Atoll, Republic of the Marshall Islands.

Figure 3-4. Potential Land Impact Area on Illeginni Islet, Kwajalein Atoll.

the first half of fiscal year 2020. The STARS launch vehicle carrying the developmental payload would be launched from KTF at PMRF in Hawai`i (Figure 3-1), and the flight would terminate at USAKA in the RMI. The following subsections include descriptions of the launch vehicle, pre-flight operations, flight, terminal phase operations, and post-flight operations.

3.2.1 Launch Vehicle Description

The Navy SSP FE-2 launch vehicle consists of a 3-stage STARS booster (Figure 3-5) and the developmental payload. The STARS booster vehicle is composed of three motor stages and control electronics. Figure 3-5 shows a typical STARS vehicle, and Table 3-1 outlines the launch vehicle characteristics. The first stage motor is 4.62 m (182 inches [in]) long with a diameter of 1.37 m (54 in) with an additional interstage section that is 87.12 centimeters (cm [34.3 in]) long with a diameter of 1.37 m (54 in). The second stage motor is 2.26 m (89 in) long with a diameter of 1.37 m (54 in), and the third stage motor is 1.32 m (52 in) long with a diameter of 1.37 m (54 in). The amount of propellant in the three boosters of a STARS vehicle totals approximately 13,608 kilograms (kg; 30,000 pounds [lb]), and the vehicle generates approximately 34,019 kg (75,000 lb) of thrust (USASMDC/ARSTRAT 2011).

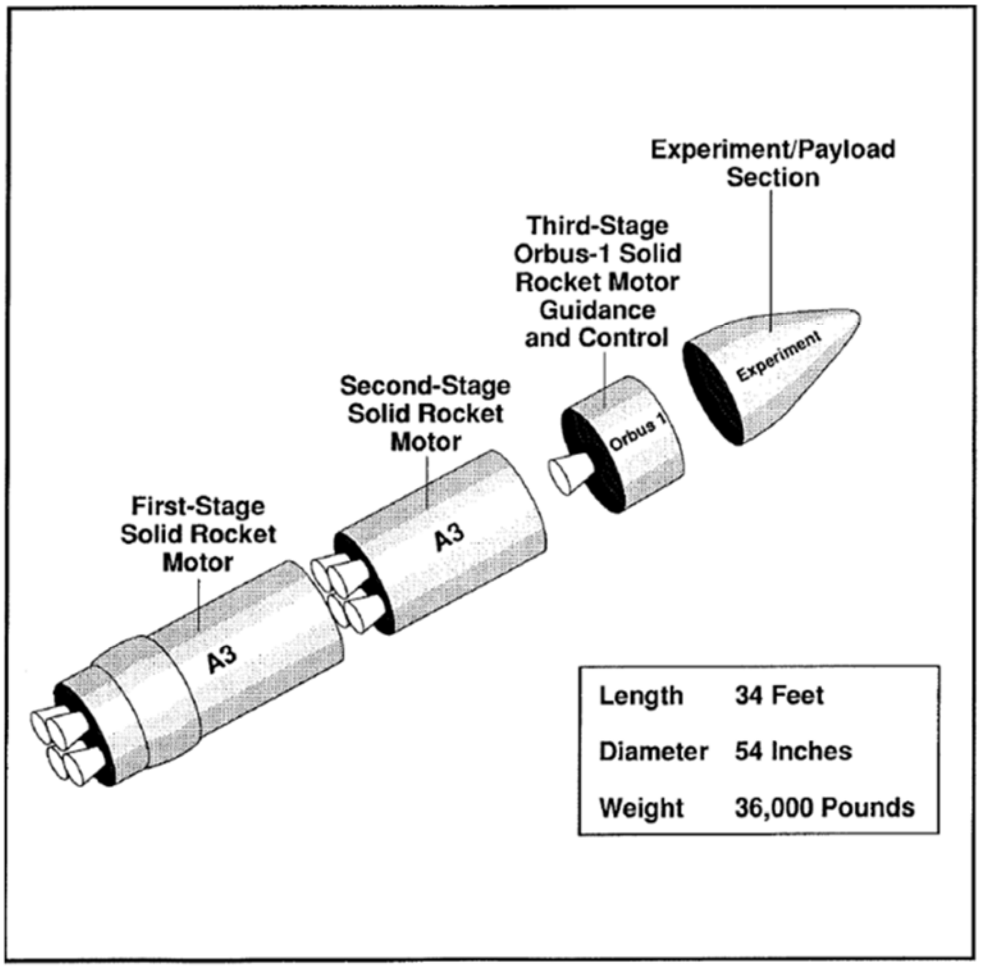

Figure 3-5. Typical Strategic Target System (STARS) Vehicle.

Table 3-1. Launch Vehicle Characteristics

Major components	Rocket motors, propellant, magnesium thorium (booster interstage)1, nitrogen gas, halon, asbestos (contained in second stage), battery electrolytes (lithium-ion, silver zinc)
Communications	Various 5- to 20-watt radio frequency transmitters; one maximum 400-watt radio frequency pulse
Power	Up to nine lithium ion polymer and silver zinc batteries, each weighing between 1.3 and 18 kg (3 and 40 lb)
Propulsion/Propellant	Rocket propellant and approximately 1.3 kg (3 lb) of pressurized nitrogen gas
Other	Small Class C (1.4) electro-explosive devices

1 The skin of the STARS first/second interstage structure was manufactured from a magnesium-thorium alloy (HK31A-H24). This is a surplus Polaris A3R asset that has been adapted to STARS, and it contains less than 3% (<80 microcuries [μCi]) of thorium. The interstage alloys are commercially available products containing magnesium-thorium alloy and are exempted from controls by the Nuclear Regulatory Commission (10 CFR 40.13) and the Radiological Procedures Protection Manual (RPPM) (Chapter 6, Attachment 6-2) since there is no physical, chemical, or metallurgical processing performed on the items.

Environmental impacts of STARS launches were analyzed in 2008 in the HRC EIS/OEIS (US Navy 2008) and in 2017 the FE-1 EA/OEA (US Navy 2017). Since environmental impacts of STARS launches at PMRF have been analyzed as a part of activities at PMRF, we do not further analyze vehicle launch in this document.

Table 3-2 details the payload system characteristics. Up to 454 kg or (1,000 lb) of tungsten will be contained in the payload. A nose fairing covers the payload until separation. This nose fairing is approximately 3.12 m (100 in) long with a diameter of 1.37 m (54 in) and then tapering to a 10.16 cm (4 in) diameter at the nose. The nose fairing is a single piece, but there are two clamshell extensions on the bottom 61 cm (24 in) in length that separate into two symmetric halves. After separation, the nose fairings are expected to fall in the second stage motor drop zone.

Table 3-2. Payload System Characteristics

Structure	Aluminum, steel, titanium, magnesium and other alloys, copper, fiberglass, chromate coated hardware, tungsten, plastic, teflon, quartz, room temperature vulcanizing silicone
Communications	Two up-to 20-watt radio frequency transmitters
Power	Up to three lithium ion polymer batteries, each weighing between 1 and 23 kg (3 and 50 lb)
Propulsion/Propellant	None
Other	Class C (1.4) electro-explosive devices for safety and payload subsystems operations

3.2.2 Pre-Flight Preparations in the BOA and at USAKA.

Sensor Coverage in the BOA. The flight path would essentially be the same as that analyzed in the *Final Environmental Assessment (EA)/Overseas Environmental Assessment for FE-1* (US Navy 2017b) and in the FE-1 BA (US Navy 2017a). A series of sensors would overlap coverage of the flight from launch at KTF until impact at USAKA. The sensors would include:

- Ground-based optics and radars at PMRF.
- Sea based sensors may include the Mobile At-Sea Sensor (MATSS), the Range Safety System onboard the US Motor Vessel *Pacific Collector*, and the Pacific Tracker.
- Additional airborne and waterborne sensors on military or commercial aircraft are not planned as part of the FE-2 flight test but might be scheduled by other agencies to collect data on FE-2.

All of these sensors are existing programs and would be scheduled for use based on availability.

Sensor Coverage at USAKA. Radars would be placed on Illeginni Islet to gather information on the payload. Up to four radar units, which would fit within a 61 cm by 38 cm by 15 cm (24 in by 15 in by 6 in) box, would be placed within the impact area and may be destroyed by payload impact. These radars are powered by on-shore generator power.

In addition to land-based radars and sensor vessel support, up to 12 self-stationing Lawrence Livermore National Laboratory Independent Diagnostic Scoring System (LIDSS) rafts may be placed in the lagoon and ocean waters near Illeginni Islet (Figure 3-6). These rafts would be equipped with battery-powered electric motors for propulsion to maintain position in the water. Two types of rafts will be used, hydrophone rafts and camera/radar rafts. Hydrophone rafts are equipped with hydrophones that are deployed off the back of the raft and hang in the water at a depth of approximately 3.7 m (12 ft). Camera rafts are equipped with stabilized cameras and/or radar as well as hydrophones as described above. Before the flight test, one or two range landing craft utility (LCU) vessels would be used to deploy the rafts. Rafts will be deployed in waters at least 4 m (13 ft) deep to avoid contact with the substrate and/or coral colonies. Sensors on the rafts would collect data during the payload descent until impact.

Figure 3-6. Notional Locations of LIDSS Rafts.

Pre-Flight Preparation at Illeginni Islet. Pre-flight preparation activities at Illeginni Islet would include several vessel round-trips and helicopter trips for equipment and personnel transport. There would be increased human activity on Illeginni Islet that would involve up to 24 persons over a 3-month period. Heavy equipment placement and use on Illeginni Islet would occur at times and be limited to transport on existing roads from the harbor to the impact area as well as in the impact area itself.

3.2.3 Flight Operations

After launch from KTF, the vehicle would be monitored during flight over the BOA by land, sea and/or air-based sensors deployed prior to launch. The FE-2 vehicle would avoid flying over the Northwestern Hawaiian Islands (NWHI) and would traverse over the BOA to Illeginni Islet in the RTS at Kwajalein Atoll (Figure 3-1). Following motor ignition and liftoff from the launch location, the first-stage motor would burn out downrange and separate from the second stage. Farther into flight, the second-stage would also burn out and separate, with the shroud assembly also being jettisoned prior to third stage ignition. Farther into flight, the third-stage would also burn out and separate from the payload. Splashdown of all three spent motor stages and the shroud assembly would occur at different points in the open ocean between 65 and 2,800 km (35 and 1,500 nm) from the launch pad. Jettison of the fairing and separation of the payload would occur outside the atmosphere. The mission planning process would avoid to the maximum extent possible all potential risks to environmentally significant areas. All actual impact zones would be sized based on range safety requirements and chosen as part of the mission analysis process.

If the launch vehicle were to deviate from its course or should other problems occur during flight that might jeopardize public safety, the onboard flight termination system (FTS) would be activated. The FTS would initiate a predetermined safe mode for the vehicle, causing it to fall towards the ocean and terminate flight. No inhabited land areas would be subject to unacceptable risks of falling debris. Computer-monitored destruct lines, based on no-impact lines, are pre-programmed for the flight safety software to avoid any debris falling on inhabited areas. An FTS on the payload would include a failsafe operation to further ensure the safety of the Marshall Islands. This failsafe requires positive action to be taken by range safety personnel to allow the payload to continue flight to the vicinity of Illeginni Islet. The FTS would also contain logic to detect a premature separation of the booster stages and initiate a thrust termination action on all of the prematurely separated stages. Thrust would be terminated by initiation of an explosive charge to vent the motor chamber, releasing pressure and significantly reducing propellant combustion. This action would stop the booster's forward thrust, causing the launch vehicle to fall along a ballistic trajectory into the ocean. The FTS would be designed to prevent any debris from falling into any protected area.

The payload would fly toward pre-designated target sites at Illeginni Islet. If data from payload onboard sensors indicate that there is insufficient energy to reach the target area, the payload would be terminated causing it to fall along a ballistic trajectory into the over-ocean flight corridor in the BOA.

Upon reaching the terminal end of the flight, the payload would impact on the non-forested northwestern end of Illeginni Islet (Figure 3-4). A crater would form as a result of this impact and leave debris containing less than 454 kg (1,000 lb) of tungsten[1]. Targeted areas for the payload would be selected to minimize impacts to reefs and identified wildlife habitats. The impact point on Illeginni Islet would be west of the forest tree line to avoid affecting sensitive bird habitat (Figure 3-4). A coral reef or shallow water impact at Illeginni is not part of the Proposed Action, would be unintentional, and is unlikely.

[1] The payload debris would include tungsten for ballast, etc., in accordance with Table 3-2; exact quantities of tungsten are unknown at this time and are not expected before the BA is completed. In order to provide an appropriate conservative assessment, a quantity of up to 454 kg (1,000 lb) of tungsten alloy is used for the environmental effects analysis.

3.2.4 Post-flight Operations

Post-flight operations may include manual cleanup of payload debris, use of heavy equipment for cleanup and repairs, retrieval of sensors, and use of remotely operated vehicles (ROVs) for underwater debris retrieval as described below.

Post-flight debris deposited on Illeginni Islet or in the adjacent ocean or lagoon would be recovered. Prior to recovery and cleanup actions at the impact site, unexploded ordnance personnel would first survey the impact site for any residual explosive materials. For a land impact at Illeginni Islet, the impact areas would be washed down if necessary to stabilize the soil. Post-flight recovery operations at Illeginni Islet will involve manual cleanup and removal of all visible experiment debris, including hazardous materials, followed by filling in larger craters with ejecta using a backhoe or grader. Repairs will be made to the impact area if necessary. US Army Garrison- Kwajalein Atoll (USAG-KA) and RTS personnel are usually involved in these operations. Any accidental spills from support equipment operations would be contained and cleaned up. All waste materials would be returned to Kwajalein Islet for proper disposal in the United States. Following cleanup and repairs to the Illeginni Islet site, soil samples would be collected at various locations around the impact area and tested for pertinent contaminants.

If an inadvertent impact occurs on the reef, reef flat, or in shallow waters less than 3 m (10 ft) deep, an inspection by project personnel would occur within 24 hours. Representatives from the National Marine Fisheries Service (NMFS) and US Fish and Wildlife Service (USFWS) would also be invited to inspect the site as soon as practical after the test. The inspectors would be invited to assess any damage to coral and other natural and biological resources and, in coordination with SSP, USAG-KA, and RTS representatives, decide on any mitigation measures that may be required.

While a shallow water impact is not planned or expected, any payload impact debris found in the shallow waters near Illeginni Islet would be removed while attempting to not further disturb or damage corals or other marine organisms. Payload recovery/cleanup operations in the lagoon and ocean reef flats would be conducted similarly to land operations when tide conditions and water depth permit. A backhoe is used to excavate the crater. Excavated material is screened for debris and the crater is usually back-filled with ejecta from around the rim of the crater. While not planned or expected, should the payload impact in the deeper waters of the atoll lagoon (up to approximately 55 m [180 ft]), a ship would be used for recovery operations and a dive team from USAG-KA or RTS would be brought in to conduct underwater searches and would attempt to recover the debris manually. If warranted due to other factors, such as significant currents or mass of the debris to be recovered, the recovery team would consider the use of ROVs instead of divers.

In general, payload recovery operations would not be attempted in deeper waters on the ocean side of the Atoll. Searches for debris would be attempted out to depths of up to 55 m (180 ft). An underwater operation similar to a lagoon recovery would be used if debris were located in this area.

3.3 Environmental Stressors Associated with the Proposed Action

The Proposed Action has the potential to directly or indirectly affect protected species and their environments. The following describes the elements of the Proposed Action that may act as stressors on biological resources: exposure to elevated sound pressure levels (SPLs), direct contact, vessel strike, exposure to chemicals and human disturbance during debris recovery and clean-up operations. These stressors are further discussed and analyzed in Section 5.0 (Effects of the Action).

3.3.1 Exposure to Elevated Sound Levels

The Proposed Action has the potential to result in elevated SPLs both in air and underwater. The primary elements of the Proposed Action that would result in elevated SPLs are: (1) sonic booms, (2) splashdown of spent motor stages and other vehicle components, and (3) impact of the payload.

The vehicle and payload would fly at high-speeds sufficient to generate sonic booms from close to launch at PMRF and extending to impact at or near Kwajalein Atoll. Sonic booms create elevated pressure levels both in air and underwater. Estimates of sonic boom location and SPLs for the FE-2 flight test have been estimated and are detailed in Appendix A and Section 5.1.1.

Elevated SPLs would occur in the ocean as spent rocket motors and other vehicle components impact the ocean's surface in the BOA. SPLs of component splashdown in ocean waters depend on the component size, shape, weight, velocity, and trajectory, as well as on air and water conditions. SPLs resulting from splashdown of vehicle components have been estimated and are detailed in Appendix A and Section 5.1.1.

Impact of the payload at the terminal end of the flight will also result in elevated sound levels. For all impact scenarios, there will be both in-air and underwater elevated sound levels. Pressure estimates from a test event using a similar amount of high explosive as the Navy payload resulted in SPLs of 140 decibels (dB) at 18 m (59 ft). These levels were used as a bounding case for FE-1 and are also used for the current FE-2 Proposed Action.

3.3.2 Direct Contact

The Proposed Action will result in spent rocket motors and nose fairings splashing down into the BOA as well as impact of the payload on land at Illeginni Islet. These falling components will directly contact aquatic and/or terrestrial habitats and have the potential to directly contact consultation species. Payload component contact with the land may result in cratering and ejecta radiating out from the point of impact. While direct estimates for cratering and ejecta field size are not available for the proposed payload, cratering and ejecta for FE-1 were expected to be less than those of Minuteman III (MMIII) reentry vehicles (RVs). Therefore, MMIII estimates of cratering and shock waves (USAFGSC and USASMDC/ARSTRAT 2015) are used as a maximum bounding case for the proposed FE-2 Action as well.

3.3.3 Vessel Strike

The Proposed Action has the potential to increase ocean vessel traffic in the Action Area during both pre-flight preparations and post-flight activities.

As part of FE-2 flight test monitoring and data collection, sea-based sensors will be deployed along the flight path on vessels in the BOA. These three vessels (Section 3.2.2) will travel from PMRF or USAKA to locations along the flight path.

Pre-flight activities at or near USAKA will include vessel traffic to and from Illeginni Islet. Prior to launch, radars will be placed on Illeginni Islet and would be transported aboard ocean-going vessels.

Sensor rafts will also be deployed near the impact site from a LCU vessel. Several vessel round trips to Illeginni Islet will be conducted for pre-flight activities.

Post-flight, payload debris recovery and clean-up will take place at Illeginni Islet. These post-test cleanup and recovery efforts will result in increased vessel traffic to and from Illeginni Islet. Several vessel round trips to Illeginni Islet will be conducted for post-flight activities. Vessels will be used to transport heavy equipment (such as backhoe or grader) and personnel for manual cleanup of debris, backfilling or any craters, and instrument recovery. Deployed sensor rafts will also be recovered by a LCU vessel. In the event of an unintended shallow water impact or debris entering the shallow water environments from a land impact, visible debris would be recovered. Smaller boats will transport divers, and ROVs if needed, to and from Illeginni Islet to locate and recover debris in waters up to approximately 55 m (180 ft) deep on the ocean or lagoon sides of Illeginni Islet.

3.3.4 Exposure to Hazardous Chemicals

The Proposed Action has the potential to introduce hazardous chemicals into the Action Area. Splash-down of vehicle and payload components have the potential to introduce propellants, battery acids, explosives, and heavy metals into the marine environment of the BOA. Land impact of the payload would have the potential to introduce propellants, battery acids, and heavy metals into the terrestrial environment of Illeginni Islet. The payload will carry less than 454 kg (1,000 lb) of tungsten. While attempts will be made to recover all tungsten and other visible debris, some may remain in the impact area at Illeginni Islet. Pre-test preparatory and post-test cleanup activities may involve heavy equipment and ocean-going vessels, which have the potential to introduce fuels, hydraulic fluids, and battery acids to terrestrial habitats as well as marine habitats. Any accidental spills from support equipment operations would be contained and cleaned up. All waste materials would be transported to Kwajalein Islet for proper disposal in the United States. A small number of small radars on Illeginni Islet are considered expendable and may be destroyed during testing. While the debris from these radars is expected to be recovered, battery acids and heavy metals may be introduced into the terrestrial environment and may potentially leech into the marine environment.

3.3.5 Disturbance from Human Activities and Equipment Operation

A minimal amount of human activity will take place in the BOA and will be limited to vessel traffic for sensor placement as described above. No post-flight FE-2 activities will take place in the BOA except for sensor carrying vessels returning to their place of origin.

At USAKA, both pre-test preparations and post-test debris recovery and cleanup activities will result in elevated levels of human activity in terrestrial and marine environments. Elevated levels of human activity are expected for approximately 10 weeks at Illeginni Islet. During this period, several vessel round-trips are likely. Helicopters will also be used to transport equipment and personnel to Illeginni Islet. The Action is expected to involve as many as two dozen personnel on Illeginni Islet during the 10-week period.

At Illeginni Islet, pre-test activities will involve site preparation and radar and other equipment placement. These pre-test activities may include use of heavy equipment such as a backhoe or grader. Post-flight activities would include retrieval of radars and other equipment, recovery of payload debris, and cleanup including possible backfilling of an impact crater. The payload impact debris will be cleaned up by hand and with heavy equipment. If impact debris or ejecta is deposited in shallow water environments, especially near coral reef habitats, it would be collected manually by divers and in some cases heavy equipment (likely a backhoe) would be used to clear debris. These activities have the potential to contact consultation organisms, disrupt animal behavior, and temporarily increase turbidity in the water.

If an inadvertent impact occurs on the reef, reef flat, or in shallow waters less than 3 m (10 ft) deep, or if project related debris enters these areas, an inspection by project personnel would occur within 24 hours. Representatives from NMFS and USFWS would also be invited to inspect the site as soon as practical after the impact. The inspectors would assess any damage to coral and other natural and biological resources and, in coordination with USAG-KA and RTS, decide on any mitigation measures that may be required.

Recovery/cleanup operations for an inadvertent payload impact in the lagoon or ocean reef flats would be conducted similarly to land operations when tide conditions and water depth permit. A backhoe would be used to excavate the crater, excavated material would be screened for debris, and the crater would usually be back-filled with substrate and materials ejected around the rim of the crater.

Should the payload inadvertently impact in the deeper waters of the Atoll lagoon or on the ocean side of Illeginni Islet (up to approximately 50 m or 180 ft), a dive team from USAG-KA or RTS would be brought in to conduct underwater searches. Using a ship for recovery operations, an ROV would be used first to locate the debris field on the lagoon bottom. Divers in scuba gear would then be able to recover the debris manually.

3.4 Mitigation Measures

The US Navy and USASMDC have proposed several discretionary mitigation measures to minimize the impacts of the Proposed Action on the environment. These discretionary mitigation measures include:

- During travel to and from impact zones, including Illeginni Islet, ship personnel would monitor for marine mammals and sea turtles to avoid potential ship strikes. Vessel operators would adjust speed or raft deployment based on expected animal locations, densities, and or lighting and turbidity conditions.
- Any observation of marine mammals or sea turtles during ship travel or overflights would be reported to the USAG-KA Environmental Engineer.
- Vessel and equipment operations would not involve any intentional discharges of fuel, toxic wastes, or plastics and other solid wastes that could harm terrestrial or marine life.
- Hazardous materials would be handled in adherence to the hazardous materials and waste management systems of USAG-KA. Hazardous waste incidents would comply with the emergency procedures set out in the Kwajalein Environmental Emergency Plan (KEEP) and the UES.
- Vessel and heavy equipment operators would inspect and clean equipment for fuel or fluid leaks prior to use or transport and would not intentionally discharge fuels or waste materials into terrestrial or marine environments.
- All equipment and packages shipped to USAKA will undergo inspection prior to shipment to prevent the introduction of alien species into Kwajalein Atoll.
- Pre-flight monitoring by qualified personnel will be conducted on Illeginni Islet for sea turtles or sea turtle nests. For at least 8 weeks preceding the FE-2 launch, Illeginni Islet would be surveyed by pre-test personnel for sea turtles, sea turtle nesting activity, and sea turtle nests. If possible, personnel will inspect the area within days of the launch. If sea turtles or sea turtle nests are

observed near the impact area, observations would be reported to appropriate test and USAG-KA personnel for consideration in approval of the launch and to NMFS.

- Personnel will report any observations of sea turtles or sea turtle nests on Illeginni to appropriate test and USAG-KA personnel to provide to NMFS.
- To avoid impacts on coral heads in waters near Illeginni Islet, sensor rafts would not be located in waters less than 4 m (13 ft) deep.
- When feasible, within one day after the land impact test at Illeginni Islet, USAG-KA environmental staff would survey the islet and the near-shore waters for any injured wildlife, damaged coral, or damage to sensitive habitats. Any impacts to biological resources would be reported to the Appropriate Agencies, with USFWS and NMFS offered the opportunity to inspect the impact area to provide guidance on mitigations.
- Although unlikely, any dead or injured marine mammals or sea turtles sighted by post-flight personnel would be reported to the USAG-KA Environmental Office and SMDC, who would then inform NMFS and USFWS. USAG-KA aircraft pilots otherwise flying in the vicinity of the impact and test support areas would also similarly report any opportunistic sightings of dead or injured marine mammals or sea turtles.
- For recovery and rehabilitation of any injured migratory birds or sea turtles found at Illeginni Islet, USFWS and NMFS would be notified to advise on best care practices and qualified biologists would be allowed to assist in recovering and rehabilitating any injured sea turtles found.
- If an inadvertent impact occurs on the reef, reef flat, or in shallow waters less than 3 m (10 ft) deep, an inspection by project personnel would occur within 24 hours. Representatives from the NMFS and USFWS would also be invited to inspect the site as soon as practical after the test. The inspectors would assess any damage to coral and other natural and biological resources and, in coordination with SSP, USAG-KA and RTS representatives, decide on any response measures that may be required.
- Debris recovery and site cleanup would be performed for land or shallow water impacts. To minimize long-term risks to marine life, all visible project-related debris would be recovered during post-flight operations, including debris in shallow lagoon or ocean waters by range divers. In all cases, recovery and cleanup would be conducted in a manner to minimize further impacts on biological resources.
- At Illeginni Islet, should any missile components or debris impact areas of sensitive biological resources (i.e., sea turtle nesting habitat or coral reef), a USFWS or NMFS biologist would be allowed to provide guidance and/or assistance in recovery operations to minimize impacts on such resources. To the greatest extent practicable, when moving or operating heavy equipment on the reef during post-test clean up, protected marine species including invertebrates will be avoided or effects to them will be minimized. This may include movement of these organisms out of the area likely to be affected.
- During post-test recovery and cleanup, should personnel observe endangered, threatened, or other species requiring consultation moving into the area, work would be delayed until such species were out of harm's way or leave the area.

4.0 LISTED SPECIES AND CRITICAL HABITAT IN THE ACTION AREA

This section introduces the species that occur or have the potential to occur in the Action Area and may be affected by the Proposed Action including a description of each species, the known distribution of the species, the population of the species in the Action Area, and status and threats to each species. The population of each species is evaluated for its current condition in each of the two portions of the Action Area: (a) the BOA including deep Hawaiian waters along the test flight corridor (Figure 3-1 and Figure 3-2) and (b) the Illeginni Islet impact zone including adjacent shallow waters (Figure 3-3 and Figure 3-4). The following species occur within the Action Area and may be affected by the Proposed Action: 25 cetacean, 1 phocid, 1 bird, 5 sea turtle, 7 fish, 22 coral, and 5 mollusk species (Table 4-1). There is no critical habitat for any species located within the Action Area.

Table 4-1
Species Requiring Consultation‡ in the Action Area

Scientific Name	Common Name	IUCN Status†	CITES Appendix	Listing Status ‡
Cetaceans				
Balaenoptera acutorostrata	Minke whale	LC	I	MMPA
B. borealis	Sei whale	EN	I	ESA-Endangered, MMPA-Depleted
B. edeni	Bryde's whale		I	MMPA
B. musculus	Blue whale	EN	I	ESA-Endangered, MMPA-Depleted
B. physalus	Fin whale	EN	I	ESA-Endangered, MMPA-Depleted
Delphinus delphis	Short-beaked common dolphin	LC	II	MMPA
Feresa attenuata	Pygmy killer whale		II	MMPA
Globicephala macrorhynchus	Short-finned pilot whale		II	MMPA
Grampus griseus	Risso's dolphin	LC	II	MMPA
Indopacetus pacificus	Longman's beaked whale		II	MMPA
Kogia breviceps	Pygmy sperm whale		II	MMPA
K. sima	Dwarf sperm whale		II	MMPA
Lagenodelphis hosei	Fraser's dolphin	LC	II	MMPA
Megaptera novaeangliae	Humpback whale	LC	I	ESA-Endangered[1], MMPA-Depleted
Mesoplodon densirostris	Blainville's beaked whale		II	MMPA
Orcinus orca	Killer whale		II	MMPA-Depleted
Peponocephala electra	Melon-headed whale	LC	II	MMPA
Physeter macrocephalus	Sperm whale	VU	I	ESA-Endangered, MMPA-Depleted
Pseudorca crassidens	False killer whale		II	ESA- Endangered (Insular Hawaiian DPS), MMPA-Depleted
Stenella attenuata	Pantropical spotted dolphin	LC	II	MMPA-Depleted
S. coeruleoalba	Striped dolphin	LC	II	MMPA
S. longirostris	Spinner dolphin		II	MMPA-Depleted
Steno bredanensis	Rough-toothed dolphin	LC	II	MMPA
Tursiops truncatus	Bottlenose dolphin	LC	II	MMPA-Depleted
Ziphius cavirostris	Cuvier's beaked whale	LC	II	MMPA
Phocids				
Neomonachus schauinslandi	Hawaiian monk seal	EN	I	ESA-Endangered, MMPA-Depleted
Birds				
Puffinus auricularis newelli	\`A\`o (Newell's shearwater)	EN		ESA-Threatened

Scientific Name	Common Name	IUCN Status†	CITES Appendix	Listing Status ‡
Sea Turtles				
Caretta caretta	Loggerhead turtle	VU	I	ESA-Endangered[2]
Chelonia mydas	Green turtle	EN	I	ESA-Threatened, Endangered[3]
Dermochelys coriacea	Leatherback turtle	VU	I	ESA-Endangered
Eretmochelys imbricata	Hawksbill turtle	CR	I	ESA-Endangered
Lepidochelys olivacea	Olive ridley turtle	VU	I	ESA-Threatened, Endangered[4]
Fish				
Alopias superciliosus	Bigeye thresher shark	VU	II	UES
Carcharhinus longimanus	Oceanic whitetip shark	VU	II	ESA-Threatened
Cheilinus undulatus	Humphead wrasse	EN	II	UES
Manta alfredi	Reef manta ray	VU	II	UES
M. birostris	Oceanic giant manta ray	VU	II	ESA-Threatened
Sphyrna lewini	Scalloped hammerhead	EN	II	ESA-Threatened (Indo-West Pacific Distinct Population Segment)
Thunnus orientalis	Pacific bluefin tuna	VU		UES
Corals				
Acanthastrea brevis		VU	II	UES
Acropora aculeus		VU	II	UES
A. aspera		VU	II	UES
A. dendrum		VU	II	UES
A. listeri		VU	II	UES
A. microclados		VU	II	UES
A. polystoma		VU	II	UES
A. speciosa		VU	II	ESA- Threatened
A. tenella		VU	II	ESA- Threatened
A. vaughani		VU	II	UES
Alveopora verrilliana		VU	II	UES
Cyphastrea agassizi		VU	II	UES
Heliopora coerulea		VU	II	UES
Leptoseris incrustans		VU	II	UES
Montipora caliculata		VU	II	UES
Pavona cactus		VU	II	UES
P. decussata		VU	II	UES
P. venosa		VU	II	UES
Pocillopora meandrina		LC	II	ESA- Candidate
Turbinaria mesenterina		VU	II	UES
T. reniformis		VU	II	UES
T. stellulata		VU	II	UES
Mollusks				
Hippopus hippopus	Giant Clam	LC	II	ESA- Candidate
Pinctada margaritifera	Black-lipped pearl oyster	NE		UES
Tectus niloticus[5]	Top shell snail	NE		UES
Tridacna gigas	Giant Clam	VU	II	ESA- Candidate
T. squamosa	Giant Clam	LC	II	ESA- Candidate

Sources: NOAA 2018a, IUCN 2018, UNEP-WCMC 2018

†IUCN: International Union for Conservation of Nature, CR: Critically Endangered, EN: Endangered, LC: Least Concern, NE: Not Evaluated, VU: Vulnerable; CITES: Convention on International Trade in Endangered Species of Wild Fauna and Flora

‡ESA: US Endangered Species Act, MMPA: Marine Mammal Protection Act, UES: UES protection (USASMDC/ARSTRAT 2018 Section 3-4.5.1). All ESA listed and candidate species are also protected under the UES where they occur in Kwajalein Atoll.

[1]The distinct population segments (DPS) of humpback whales likely in the Action Area are not listed under the ESA; however, there is some uncertainty about which DPS whales in the Action Area belong to (see Section 4.1.14).

[2]North Pacific Ocean DPS.

[3]The green turtle is currently listed based on DPSs. Green turtles in the Action Area may belong to two DPSs; the central west Pacific DPS includes turtles in the Marshall Islands and is listed as endangered while turtles around Hawaii are in the central north Pacific DPS and are listed as threatened (Seminoff et al 2015, NOAA 2018a).

[4]As a species, the olive ridley turtle is listed as threatened, but the Mexican Pacific Coast nesting population is listed as endangered. Some olive ridley turtles in the Action Area may be from this east Pacific Coast nesting population (NMFS and USFWS 2007a, NMFS and USFWS 2014).

[5]Within RMI legislation *Tectus niloticus* is inclusive of *Trochus maximus, Trochus niloticus, and Tectus maximus*. Most biological authorities currently synonymize all of these under the name *Tectus niloticus*.

4.1 Marine Mammals

Multiple species of cetaceans and Hawaiian monk seals are the only marine mammals that have been documented in the Action Area, and thus, are the only marine mammals analyzed in this BA. The dugong (*Dugong dugong*) may have occurred historically at Kwajalein Atoll according to an appendix of the UES. However, because this species has not been reported in the vicinity of the Action Area for many decades, it is not included in this BA and is excluded from consultation. Hawaiian monk seals are the only pinnipeds known to occur in the Action Area. The following section provides general information on the distribution, population status, habitat preferences, and hearing ability (if known) of marine mammal species that may occur in the Action Area. Twenty-five cetacean species have the potential to occur in the Action Area (Table 4-1), six of which are listed under the ESA as endangered. All marine mammals discussed in this section are also protected under the MMPA (16 USC § 1361 et seq.).

Any species listed as threatened or endangered under the ESA is considered a depleted stock under the MMPA. The term depleted is defined by the MMPA as any case in which a species or population stock is determined to be below its optimum sustainable population. In addition to those species listed as depleted under the MMPA because they are listed as threatened or endangered under the ESA, four other cetacean species are also listed as depleted under the MMPA even though these species are not ESA listed (Table 4-1).

There is no designated critical habitat in the Action Area for marine mammals. While Hawaiian monk seal critical habitat does not occur in the Action Area, a discussion of monk seal critical habitat is included in Section 4.1.26 due to the proximity of Hawaiian monk seal critical habitat to the Action Area.

Summary of Threats to Cetaceans. Potential threats to cetacean species in the BOA and deep ocean waters near the RMI include ingestion of marine debris, entanglement in fishing nets or other marine debris, collision with vessels, loss of prey species due to new seasonal shifts in prey species or overfishing, excessive noise above baseline levels in a given area, chemical and physical pollution of the marine environment, parasites and diseases, and changing sea surface temperatures due to global climate change. These threats are not particular to ESA or UES listed species, but the death of an individual is a higher cost to populations with low numbers.

Noise Exposure and Cetaceans. There are many different sources of noise in the marine environment, both natural and anthropogenic. Biologically produced sounds include whale songs, dolphin clicks, and fish vocalizations. Natural geophysical sources include wind-generated waves, earthquakes, precipitation, wave action, and lightning storms. Anthropogenic sounds are generated by a variety of activities, including commercial shipping, geophysical surveys, oil drilling and production, dredging and construction, sonar, DoD test activities and training maneuvers, and oceanographic research (USAF 2006).

While measurements for SPLs in air are referenced to (re) 20 micropascals (μPa), underwater sound levels are normalized to 1 μPa at 1 m (3.3 ft) from the source, a standard used in underwater sound measurement. In the Action Area, some of the loudest underwater sounds generated are most likely to originate from storms, ships, and some marine mammals. Thunder can have source levels of up to 260 dB (re 1 μPa). A passing supertanker can generate up to 190 dB (re 1 μPa) of low frequency sound.

There is increasing evidence that loud underwater noise can be lethal, physically damaging, or disruptive to cetaceans (Miller 2007). Cetaceans have been observed altering their vocalizations in the presence of underwater anthropogenic noises and avoiding some underwater sounds, even vacating feeding or mating grounds, changing migratory routes, or suspending feeding (Miller 2007). Certain cetaceans are affected by elevated noise levels more than others. The beaked whales (Ziphiidae) and other deep diving species seem to be particularly susceptible to acoustic damage and anthropogenic noise has been linked to strandings in some species (Miller 2007, Ellis and Mead 2017).

Summary of Cetaceans in the BOA. Nine cetacean species are considered likely to occur in the BOA portion of the Action Area between the Hawaiian Islands and Kwajalein Atoll: minke whale, sei whale, Bryde's whale, blue whale, short-finned pilot whale, melon headed whale, sperm whale, pantropical spotted dolphin, and striped dolphin (Table 4-2). Nine other cetaceans are considered to have the potential to occur in the BOA of the Action Area. Some of these species occur only seasonally for breeding or during particular points in the migration patterns. Migratory paths of these species are discussed in Section 4.1 and used when determining the likelihood of occurrence in the BOA.

Summary of Cetaceans Near Kwajalein Atoll. Of the 25 cetacean species that have ranges overlapping the Action Area, 11 species are considered likely to occur or have the potential to occur in the ocean waters of Kwajalein Atoll near Illeginni Islet (Table 4-2). These species are sometimes seasonal in occurrence because of unique migration patterns. Due to the migratory nature of cetaceans, it is difficult to determine the densities of each of the species at any particular moment. Though distribution data are largely lacking, any of the species occurring in the RMI have the potential to occur around Illeginni Islet (Table 4-2). Information regarding life history, including feeding patterns, known distribution, and migration patterns, were used to determine the status of these species in the vicinity of Illeginni Islet.

Table 4-2
Marine Mammal Presence in the Broad Ocean Area (BOA) and near Illeginni Islet.

			Likelihood of Occurrence:	
Common Name	**Scientific Name**	**ESA Listing Status[1]**	**in the BOA**	**Near Illeginni Islet**
Cetaceans				
Minke whale	*Balaenoptera acutorostrata*	-	L	P
Sei whale	*B. borealis*	E	L	U
Bryde's whale	*B. edeni*	-	L	P
Blue whale	*B. musculus*	E	L	U
Fin whale	*B. physalus*	E	P	U
Short-beaked common dolphin	*Delphinus delphis*	-	U	P
Pygmy killer whale	*Feresa attenuata*	-	P	U
Short-finned pilot whale	*Globicephala macrorhynchus*	-	L	L
Risso's dolphin	*Grampus griseus*	-	P	U
Longman's beaked whale	*Indopacetus pacificus*	-	P	U
Pygmy sperm whale	*Kogia breviceps*	-	P	U
Dwarf sperm whale	*K. sima*	-	P	U
Fraser's dolphin	*Lagenodelphis hosei*	-	P	U
Humpback whale	*Megaptera novaeangliae*	E	P	U
Blainville's beaked whale	*Mesoplodon densirostris*	-	P	U
Killer whale	*Orcinus orca*	-	P	P
Melon-headed whale	*Peponocephala electra*	-	L	P
Sperm whale	*Physeter macrocephalus*	E	L	L
False killer whale	*Pseudorca crassidens*	E, Insular Hawaiian DPS	P	U
Pantropical spotted dolphin	*Stenella attenuata*	-	L	P
Striped dolphin	*S. coeruleoalba*	-	L	P
Spinner dolphin	*S. longirostris*	-	P	L
Rough-toothed dolphin	*Steno bredanensis*	-	P	U
Bottlenose dolphin	*Tursiops truncatus*	-	P	P
Cuvier's beaked whale	*Ziphius cavirostris*	-	P	U
Phocids				
Hawaiian monk seal	*Neomonachus schauinslandi*	E	P	U

Sources: See species descriptions in Section 4.1.
[1] All species in this table are protected under the Marine Mammal Protection Act (MMPA) and all species in this table are protected under the UES where they occur in waters of the Marshall Islands.
E=Endangered, L=Likely; P=Potential; U=Unlikely or does not occur in the portion of the Action Area

4.1.1 Minke Whale (*Balaenoptera acutorostrata*)

Species Description. The common minke whale is a type of baleen whale that is protected under the MMPA and is not listed under the ESA. Minke whales reach lengths of approximately 9 m (30 ft) and weigh up to 9 metric tons (20,000 lb; NOAA 2018a) They are primarily lunge feeders, often plunging through patches of shoaling fish, krill, or copepods (Hoelzel et al. 1989, Bannister 2002). Depending on the primary prey availability, these whales are also known to do surface feeding including surface maneuvers and feeding strikes (Kuker et al. 2005). In terms of functional hearing capability, minke whales belong to low-frequency cetaceans, which have the best hearing ranging from 7 hertz (Hz) to 22 kilohertz (kHz) (Southall et al. 2007). Minke whales, like other baleen whales, are known to use low-frequency sounds to communicate with one another (NOAA 2018a).

Distribution. The distribution of minke whales is considered cosmopolitan with three stocks in the Pacific (Carretta et al. 2014). These whales feed mostly in cool temperate to boreal waters at higher latitudes but are also found in tropical and subtropical areas (NOAA 2018a). Whales found in extreme northern areas generally migrate annually between low-latitude breeding grounds in the winter and high-latitude feeding grounds in the summer (Carretta et al. 2014, Kuker et al. 2005). While in waters off Washington and central California, whales may establish home ranges (Carretta et al. 2014, Kuker et al. 2005). Minke whales are usually seen over continental shelves and occur seasonally (October to April) around the Hawaiian Islands (Carretta et al. 2014). The migration routes and destinations for whales migrating from near the Hawaiian Islands are unknown (Carretta et al. 2014).

Threats. Minke whales are susceptible to the same potential threats that are generally applicable to all cetacean species known to occur in the Action Area. The primary listing threats for this species are whaling, entanglement in fishing gear, vessel strikes, and ocean noise, as these whales use low-frequency sounds to communicate with one other (NOAA 2018a). There are no known threats in the Action Area that are specific to only minke whales.

Populations in the Action Area.
Broad Ocean Area: This species is likely to occur in the Action Area seasonally. Minke whales are known to occur near the Hawaiian Islands (approximately October – April); however, no abundance estimates are available for this area (Carretta et al. 2014). Minke whales were also detected on surveys conducted between the Hawaiian Islands and Guam via Wake Island (PIFSC 2010a, PIFSC 2010b). One minke whale was sighted on a January/February 2010 cruise (PIFSC 2010a), and there were 23 acoustic detections of the species on the April/May 2010 cruise (PIFSC 2010b).

Vicinity of Illeginni Islet: While minke whales are known to occur in the deep ocean areas of the RMI (Reeves et al. 1999, Miller 2007), this species is not known to occur in the vicinity of Illeginni Islet. There is no available information on the abundance of minke whales in the deep ocean areas of the RMI.

4.1.2 Sei Whale (*Balaenoptera borealis*)

Species Description. Sei whales are endangered under the ESA throughout their range and depleted under the MMPA. Sei whales reach lengths of 12 to 18 m (40 to 60 ft) and weigh up to 45 metric tons (100,000 lb; NOAA 2018a). The sei whale is a type of baleen whale, which typically skims to obtain its food, but occasionally does some lunging and gulping (Horwood 2009). Feeding occurs primarily around dawn, which appears to be correlated with vertical migrations of prey species (Horwood 2009), which consist primarily of schooling fish (Bannister 2002). Sei whales are in the low-frequency cetaceans functional hearing group with an estimated auditory bandwidth of 7 Hz to 22 kHz (Southall et al. 2007).

Distribution. Sei whales have a worldwide distribution and are found primarily in cold temperate to subpolar latitudes. Only a single eastern North Pacific stock is recognized in the US Pacific Exclusive Economic Zone (EEZ; Carretta et al. 2014). However, some research indicates that more than one stock exists: one between 175° W and 155° W and another east of 155° W (Carretta et al. 2014). Sei whales 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) and are usually observed in deeper waters of oceanic areas far from the coastline (NOAA 2018a). Sei whales spend the summer feeding in high subpolar latitudes from 35° N to 50° N and return to lower latitudes from 20° N to 23° N to calve in winter (Horwood 2009, Smultea et al. 2010). They are considered absent or at very low densities in most equatorial areas; however, sei whales have been observed near Hawai`i (Carretta et al. 2014).

Threats. The eastern North Pacific population has been protected since 1976 but is likely still impacted by the effects of continued unauthorized takes (Carretta et al. 2014). Sei whales are susceptible to the same potential threats that are generally applicable to all cetacean species known to occur in the Action Area. The primary listing threats for this species are entanglement in fishing gear, vessel strikes, and ocean noise which interrupts their normal behavior (NOAA 2018a). There are no known threats in the Action Area that are specific to only sei whales.

Populations in the Action Area.
Broad Ocean Area: The sei whale is considered rare in the Hawai`i portion of the BOA, based on sighting data and the species' preference for cool temperate waters. Sei whales have been observed in shipboard surveys of the Hawaiian Islands EEZ in 2002 and 2010 (Carretta et al. 2014) and in a 2007 study (Smultea et al. 2010). These fall/winter 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). A 2010 shipboard line-transect surveys of the Hawaiian Islands stock resulted in a summer/fall abundance estimate of 178 (coefficient of variation [CV] = 0.9) sei whales (Carretta et al. 2014). This abundance estimate is considered the best available for the US EEZ off the coast of Hawai`i, but it 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. 2014). Sei whales have also been observed during surveys conducted between the Hawaiian Islands and Guam via Wake Island (PIFSC 2010a, PIFSC 2010b). Three sei whales were sighted on a January/February 2010 cruise (PIFSC 2010a) and there was one observation of a sei or Bryde's whale in both January/February and April/May 2010 cruises (PIFSC 2010b).

Vicinity of Illeginni Islet: This species is not known to occur in the vicinity of Illeginni Islet. Sei whales have not been observed in the deep ocean waters of the RMI but given their presence in the central and western Pacific, they are potentially present here (Reeves et al. 1999; Miller 2007). There is no available information on the abundance of sei whales in the RMI.

4.1.3 Bryde's Whale (*Balaenoptera edeni*)

Species Description. This species is protected under the MMPA and is not listed under the ESA. In the North Pacific, Bryde's whales have mean lengths at sexual maturity of 13 m (43 ft) for males and 13.5 m (44 ft) for females and weigh around 15 to 17 metric tons (33,000 to 37,500 lb; Kato 2002). Bryde's whales are a type of baleen whale, which primarily feed on schooling fish as well as krill and other pelagic crustaceans by lunge feeding (Bannister 2002). The Bryde's whale does not have a well-defined breeding season. Inshore stocks may breed throughout the year while pelagic whales are thought to breed principally in autumn (Kato 2002). Bryde's whales are low-frequency cetaceans, which have functional hearing ranging from 7 Hz to 22 kHz (Southall et al. 2007).

Distribution. Bryde's whales have a cosmopolitan distribution and are found in tropical and warm temperate oceans from 40º S to 40º N year-round (Kato 2002). Bryde's whales inhabiting US waters have been divided into three management stocks: the eastern tropical Pacific stock, the Hawaiian stock, and the northern Gulf of Mexico stock (Carretta et al. 2016). Some populations of Bryde's whales migrate seasonally while other populations are residents (NOAA 2018a). For those populations that migrate, long migrations are not typical, only limited shifts in distribution toward and away from the equator, in winter and summer, have been observed (Best 1996). Bryde's whales spend most of their time at or near the surface (Alves et al. 2010). During deeper dives, Bryde's whales might dive for as long as 10 minutes and to depths of 180 m (590 ft; Alves et al. 2010). They are sometimes seen very close to shore and even inside enclosed bays (Best 1996).

Threats. Bryde's whales are susceptible to the same potential threats that are generally applicable to all cetacean species known to occur in the Action Area. Bryde's whales may be particularly affected by vessel strikes, low-frequency underwater noise, and whaling (NOAA 2018a). There are no known threats in the Action Area that are specific to only Bryde's whales.

Populations in the Action Area.
Broad Ocean Area: Bryde's whales are known to occur within the Hawaiian Islands and adjacent high seas waters. A 2010 shipboard line-transect survey of the Hawaiian Islands EEZ resulted in an estimate of 798 (CV = 0.28) Bryde's whales (Carretta et al. 2014). No current estimate of abundance for the eastern tropical Pacific stock of Bryde's whales is available (Carretta et al. 2016). Bryde's whales may have been detected on surveys conducted between the Hawaiian Islands and Guam via Wake Island (PIFSC 2010a, PIFSC 2010b). One sei or Bryde's whale was sighted on a January/February 2010 cruise (PIFSC 2010a) and one sei or Bryde's whale was sighted on the April/May 2010 cruise (PIFSC 2010b).

Vicinity of Illeginni Islet: Bryde's whales have been identified in many Pacific island chains, including the RMI (Miller 2007). However, this species is not known to occur in the vicinity of Illeginni Islet. In a cruise conducted by Shimada et al. (2003), 10 Bryde's whales were sighted between 7° N and 19° N and 156° E and 169° E. There is no available information on the abundance of Bryde's whales in the RMI.

4.1.4 Blue Whale (*Balaenoptera musculus*)

Species Description. Blue whales are listed as endangered throughout their range under the ESA and as depleted under the MMPA. Blue whales have been recorded at lengths up to 33.6 m (110 ft), and adults generally weigh 80-150 metric tons (176,000 to 330,000 lb; Sears 2002). This species is a type of baleen whale, which preys almost exclusively on various types of zooplankton, especially krill (Bannister 2002). While blue whales sometimes surface feed, these whales more often lunge feed by diving at least 100 m (330 ft) for 8-15 minutes (Sears 2002). Like other Balaenopterids, blue whales belong to the low-frequency functional hearing group, with hearing ranging from 7 Hz to 22 kHz (Southall et al. 2007). Blue whales breed and calve in late fall through winter (Sears 2002).

Distribution. The blue whale inhabits all oceans of the world and while they are sometimes found in coastal waters, they are predominantly found offshore (Sears 2002). Blue whales in the North Pacific are divided into two management stocks; the eastern Pacific management stock and the central Pacific management stock. The central Pacific management stock migrates seasonally between summer feeding grounds in the north-central Pacific and wintering areas in lower latitudes of the western Pacific and less frequently the central Pacific including Hawai`i (Carretta et al. 2014). Blue whales are most often observed alone or with one to two individuals but can be found in groups of 50 or more in very productive areas (Sears 2002). Calving occurs in winter (Sears 2002) and likely in tropical and subtropical waters (Jefferson et al. 2008).

Threats. Widespread whaling over the last century is believed to have decreased the population to approximately 1% of its pre-whaling population size (Sirovic et al. 2004). Blue whales are susceptible to the same potential threats that are generally applicable to all cetacean species known to occur in the Action Area. There are no known threats in the Action Area that are specific to only blue whales; however, due to the small population size, vessel strikes, fisheries interactions, ocean noise, habitat degradation, pollution, and climate change (NOAA 2018a) are all significant threats for this species.

Populations in the Action Area.
Broad Ocean Area: Blue whales are found in the Hawai`i portion of the BOA; however, this species is known to occur seasonally in this region, and sighting frequency is low. Whales feeding in the north-central Pacific likely migrate to offshore waters north and west of Hawai`i in winter (Carretta et al. 2014). The best available population estimate for the eastern tropical Pacific stock of blue whales, 1,400 whales, is from 1993 (Carretta et al. 2014). Two blue whales were observed during 2010 surveys of the Hawaiian EEZ and additional observations have been made by longline vessels and from acoustic recordings off Oahu and Midway Islands (Carretta et al. 2014). Shipboard line-transect surveys in 2010 resulted in a summer/fall estimate of 81 (CV = 1.14) blue whales in the Hawaiian Islands EEZ (Carretta et al. 2014). This estimate may be an underestimate since most blue whales are expected to be at higher latitude during the summer (Carretta et al. 2014). Blue whales have also been detected during surveys of the Mariana Islands to the west of the Action Area (Department of the Navy 2014).

Vicinity of Illeginni Islet: This species is not known to occur in the vicinity of Illeginni Islet. However, blue whale range includes the deep ocean waters of the RMI. Blue whales have been sighted in areas surrounding the RMI (Reeves et al. 1999, Miller 2007). Blue whales have been recorded in Tonga and may breed in these areas, migrating from feeding waters off New Zealand (Balcazar et al. 2015). There is no available information on the abundance of blue whales in the RMI.

4.1.5 Fin Whale (*Balaenoptera physalus*)

Species Description. Fin whales are listed as endangered throughout their range under the ESA and depleted under the MMPA. The fin whale, which is a baleen whale, is the second largest species of whale (Jefferson et al. 2008) reaching lengths in the northern hemisphere of 22.5 and 21 m (74 and 69 ft) for females and males respectively (Aguilar 2002). This species uses a variety of habitats and is highly adaptable, typically following prey off the continental shelf (Azzellino et al. 2008; Panigada et al. 2008). Fin whales feed on krill and other planktonic crustaceans, schooling fish, and small squid, consuming up to one ton of prey per day in the summer (Aguilar 2002). Migration habits in the Pacific are not well known but likely depend on prey availability (Aguilar 2002). Fin whales in the northern hemisphere mate and calve December through February (Aguilar 2002). In terms of functional hearing capability, fin whales belong to the low-frequency group, with hearing ranging from 7 Hz to 22 kHz (Southall et al. 2007).

Distribution. The fin whale is found in all the world's oceans (Jefferson et al. 2008). This whale inhabits deep, offshore waters in temperate to polar latitudes, and less often in tropical latitudes (NOAA 2018a, Reeves et al. 2002). Fin whales are also often seen close to shore after periodic patterns of upwelling and the resultant increase in the density of krill upon which they feed (Azzellino et al. 2008). Pacific fin whale population structure is not well known. There are three recognized stocks of fin whales in the north Pacific: the Hawai`i stock, the California/Oregon/Washington stock, and the Alaska stock (Carretta et al. 2014).

Threats. Fin whales are susceptible to the same potential threats that are generally applicable to all cetacean species known to occur in the Action Area. Major threats for this species include vessel strikes, entanglement, and ocean noise which can interrupt normal behavior and diving (NOAA 2018a). There are no known threats in the Action Area that are specific to only fin whales.

Populations in the Action Area.
Broad Ocean Area: The distribution of fin whales in the Pacific during the summer includes the Hawai`i portion of the BOA to 32° N (Barlow 1995). They have been recorded in the eastern tropical Pacific but are considered rare there (Hamilton et al. 2009). They are occasionally found in Hawaiian waters but are generally considered rare in this portion of the BOA as well (Carretta et al. 2014). Based on 1999 passive acoustic hydrophone surveys north of Oahu, researchers estimate an average density of 0.027 calling fin whales per 1000 square kilometers (km^2; per 39 square miles [mi^2]) within about 16 km (8.6 nm) of shore (Carretta et al. 2014). The current best available abundance estimate for the Hawaiian stock of fin whales is 58 (CV = 1.12) base on shipboard line-transects in 2010 (Carretta et al. 2014). Fin whales have also been detected in surveys of the Mariana Islands to the west of the Action Area (Department of the Navy 2014).

Vicinity of Illeginni Islet: This species is not known to occur in the vicinity of Illeginni Islet, and little or no information is available regarding the population of fin whales in the RMI. These whales do occur in the central and western Pacific Ocean, which includes the RMI (Reeves et al. 1999; Miller 2007).

4.1.6 Short-beaked Common Dolphin (*Delphinus delphis*)

Species Description. Short-beaked common dolphins are protected under the MMPA and are not listed under the ESA. These small, 2 m (6 ft) long dolphins are usually found in large social groups of hundreds of individuals composed of smaller (20-30 dolphins) subunits (Perrin 2002a, NOAA 2018a). Short-beaked common dolphins are often active at the surface and are capable of diving to at least 200 m (650 ft) to feed on fish (NOAA 2018a). Common dolphins are often found near underwater features such as ridges, continental shelves, and seamounts with abundant prey (NOAA 2018a). In the eastern tropical Pacific, calving takes place all year but may be more seasonal in populations at higher latitudes (NOAA 2018a). Functional hearing for the short-beaked common dolphin is estimated to occur between approximately 150 Hz and 160 kHz, placing them among the group of cetaceans that can hear mid-frequency sounds (Southall et al. 2007).

Distribution. This relatively common species prefers warm tropical to cool tropical waters from about 60° N to 50° S in habitats with upwelling (Perrin 2002a). Although short-beaked common dolphins primarily occur in deep waters beyond the edge of the continental shelf, they do come into continental shelf waters in some season (Jefferson et al. 2008) in areas where waters are 200-2,000 m (650-6,500 ft) deep (NOAA 2018a). Cañadas and Hammond (2008) observed that groups of short-beaked common dolphins with calves and groups that were feeding preferred more coastal waters. The short-beaked common dolphin is not considered to be a truly migratory species, although seasonal shifts which vary with ocean conditions have been documented in the eastern Pacific (Perrin 2002a). In the north Pacific, short-beaked common dolphins are found primarily off the coast of North America, north of the Hawaiian Islands, and near Japan south to New Zealand (Perrin 2002a, IUCN 2015).

Threats. Short-beaked common dolphins are susceptible to the same potential threats that are generally applicable to all cetacean species known to occur in the Action Area. There are no known threats in the Action Area that are specific to only short-beaked common dolphins.

Populations in the Action Area.
Broad Ocean Area: This species is not likely to occur in the BOA of the Action Area but has been documented in central and western Pacific waters (Reeves et al. 1999; Miller 2007).

Vicinity of Illeginni Islet: This species is not known to occur in the vicinity of Illeginni Islet. Since the short-beaked common dolphin has been documented in the central and western Pacific Ocean in the Cook Islands, Fiji, and in the deep ocean areas of the RMI (Reeves et al. 1999; Miller 2007), it is considered to have the potential to occur near Illeginni Islet.

4.1.7 Pygmy Killer Whale (*Feresa attenuata*)

Species Description. Pygmy killer whales are protected under the MMPA and are not listed under the ESA. The average length of pygmy killer whale specimens is 2.3 m (7.6 ft; Donahue and Perryman 2002). Reproductive and life history information is almost completely lacking for this species; however, they are thought to occur in groups of 50 or less and feed primarily on squids and fishes (Donahue and Perryman 2002). While no empirical data on hearing ability for this species are available, functional hearing is estimated to occur between approximately 150 Hz and 160 kHz, placing them among the group of cetaceans that can hear mid-frequency sounds (Southall et al. 2007).

Distribution. The pygmy killer whale has been observed in tropical and subtropical waters around the globe (Donahue and Perryman 2002). The open ocean range of the pygmy killer whale generally extends along the equatorial regions south of 40° N (Donahue and Perryman 2002). In the Pacific, pygmy killer whales are known to occur in the eastern tropical Pacific, the waters around Hawai`i, and near Japan (Donahue and Perryman 2002). Around the main Hawaiian Islands, pygmy killer whales were seen at an average distance of 401 m (1,315 ft) from shore in a habitat use study (Baird et al. 2013). Migrations or seasonal movements of this type of toothed whale are not known.

Threats. Pygmy killer whales are susceptible to the same potential threats that are generally applicable to all cetacean species known to occur in the Action Area. There are no known threats in the Action Area that are specific to only pygmy killer whales.

Populations in the Action Area.
Broad Ocean Area: This nearshore species may occur in the BOA of the Action Area; however, it is not likely to occur here. The only documented occurrences in the western Pacific Ocean are in French Polynesia. The pygmy killer whale has been documented in the Hawaiian Islands but is considered rare in these waters and is thought to remain in resident populations within 20 km (11 nm) of shore (Carretta et al 2014). A 2010 shipboard line-transect survey of the Hawaiian Islands EEZ resulted in an estimate of 3,444 (CV = 0.52) pygmy killer whales in this area (Carretta et al. 2014).

Vicinity of Illeginni Islet: This species is not known to occur in the vicinity of Illeginni Islet. There are no documented pygmy killer whale occurrences in the deep ocean areas of the RMI (Reeves et al. 1999; Miller 2007). In the western Pacific Ocean, the only documented occurrences are in French Polynesia.

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

Species Description. Short-finned pilot whales are protected under the MMPA and are not listed under the ESA. The short-finned pilot whale is a 1.9 to 7.2 m (6.2 to 23.6 ft) long delphinid (Bernard and Reilly 1999). These whales occur in groups of 5 to 50 animals (Bernard and Reilly 1999) and feed primarily on squid, octopus, and fish in waters 305 m (1,000 ft) deep or more (NOAA 2018a). Short-finned pilot whales near Japan had a peak breeding season in April and May and birth of calves in July and August; however, a small number of births were recorded year-round (Bernard and Reilly 1999). The region of best hearing for pilot whales is believed to be between 11.2 and 50 kHz with relatively poor high frequency hearing, compared with other odontocete species and auditory thresholds as low as 50 dB re 1 µPa (Pacini et al. 2010). Pilot whales are in the mid-frequency cetaceans functional hearing group (Southall et al. 2007).

Distribution. The short-finned pilot whale is widely distributed throughout most tropical and warm temperate waters of the world (Bernard and Reilly 1999). The distribution of this species varies seasonally and is likely related to the seasonal abundance of squid (Olson and Reilly 2002). This species occurs in deep offshore areas, waters over the continental shelf break, in slope waters, and in areas of high topographic relief (Olson and Reilly 2002). In the northern Pacific, short-finned pilot whales likely occur throughout tropical and warm temperate waters and have been recorded as far north as Alaska (Bernard and Reilly 1999). There are two recognized management stocks in US waters of the Pacific: the west coast and the Hawai`i stocks.

Threats. Short-finned pilot whales are susceptible to the same potential threats that are generally applicable to all cetacean species known to occur in the Action Area. There are no known threats in the Action Area that are specific to only short-finned pilot whales. Current predominant threats to short-finned pilot whales include entanglement in fishing gear, hunting, and vessels strikes (NOAA 2018a).

Populations in the Action Area.
Broad Ocean Area: This species is commonly observed around the Hawaiian Islands (Carretta et al. 2014) and likely occurs in surrounding deeper offshore areas. In a 2013 habitat-use study off the main Hawaiian Islands, short-finned pilot whales were observed at their highest rates in slope waters (500 to 2,500 m [1,640 to 8,202 ft)] deep) throughout the year (Baird et al. 2013). Shipboard line-transect surveys of the Hawaiian Islands EEZ in 2010 resulted in an estimate of 12,422 (CV = 0.43) short-finned pilot whales (Carretta et al. 2014). Short-finned pilot whales were also detected on surveys conducted between the Hawaiian Islands and Guam via Wake Island (PISFC 2010a; PISFC 2010b). One individual was sighted on an April/May 2010 cruise and acoustic detections were also made during this cruise (PISFC 2010b).

Vicinity of Illeginni Islet: There have been documented occurrences of the short-finned pilot whale in the central and western Pacific Ocean and in the deep ocean areas of the RMI (Reeves et al. 1999; Miller 2007). On May 6, 2006, there were eight short-finned pilot whales reported near Illeginni Islet (USAF 2007). There are no abundance estimates available for the deep ocean areas of the RMI.

4.1.9 Risso's Dolphin (*Grampus griseus*)

Species Description. Risso's dolphins are protected under the MMPA and are not listed under the ESA. These dolphins are blunt-headed delphinids up to 4.1 m (13.5 ft) long (Kruse et al. 1999). These gregarious dolphins may form groups of several hundred individuals comprised of smaller subgroups (Kruse et al. 1999). Risso's dolphins are believed to feed primarily on cephalopods at night (Kruse et al.

1999). During typical surfacing sequences, these dolphins surface every 7 seconds; however, individuals may remain submerged on dives as long as 30 minutes (Kruse et al. 1999). Little is known about reproduction of Risso's dolphins, but there may be a peak in calving during the winter months (Baird 2002b). Nachtigall et al. (1995) measured hearing in an adult Risso's dolphin in a natural setting and found that adult hearing ranged from 4 to 64 kHz with thresholds as low as 63.7 dB at 8 kHz (Kruse et al. 1999). Risso's dolphins are among the group of cetaceans that are categorized as mid-frequency cetaceans (Southall et al. 2007).

Distribution. Risso's dolphins occur in temperate, subtropical, and tropical waters throughout the world (NOAA 2018a) from between 60° N and 60° S (Kruse et al. 1999). These dolphins are most commonly found seaward of the continental slope in waters that are generally greater than 1,000 m (3,300 ft; NOAA 2018a) and are known to frequent seamounts and other areas with steep bottom topography (Kruse et al. 1999). These dolphins are commonly found in waters between 15 and 20 degrees Celsius (° C, or 59 and 68 degrees Fahrenheit [°F]) and are not known to occur in waters below 10 °C (50 °F; Baird 2002b). Risso's dolphins are known to have seasonal shifts in abundance in some portions of their range which may be due to shifting prey abundance, but in some portions of their range there is evidence that abundance remains relatively constant throughout the year (Kruse et al. 1999). Populations of this species occur near Japan, in the eastern tropical Pacific, the US west coast, and around the Hawaiian Islands (Carretta et al. 2014).

Threats. Risso's dolphins are susceptible to the same potential threats that are generally applicable to all cetacean species known to occur in the Action Area. Some of the major threats to these dolphins include entanglement in fishing gear, hunting, ocean noise and contaminants that bioaccumulate in their prey (NOAA 2018a). There are no known threats in the Action Area that are specific to only Risso's dolphins.

Populations in the Action Area.
Broad Ocean Area: This species is not likely to occur in the BOA of the Action Area. There is a small stock of Risso's dolphins in the Hawaiian Islands EEZ and adjacent high seas waters (Carretta et al. 2014). A 2010 shipboard line-transect survey of the Hawaiian Islands EEZ resulted in an abundance estimate of 7,256 (CV = 0.41) Risso's dolphins (Carretta et al. 2014).

Vicinity of Illeginni Islet: This species is not known to occur in the vicinity of Illeginni Islet. There are documented occurrences of Risso's dolphins in the central and western Pacific Ocean in the Cook Islands, French Polynesia, and Guam, but there are no documented occurrences in the deep ocean areas of the RMI (Reeves et al. 1999; Miller 2007).

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

Species Description. Longman's beaked whales are protected under the MMPA and are not listed under the ESA. This is a rare beaked whale species that grows to lengths of 6-8 m (20-26 ft; Anderson et al 2006). Little information is available on life history for this species of toothed whale, but feeding is believed to be similar to other beaked whales (NOAA 2018a). Longman's beaked whales likely dive deep to forage primarily on cephalopods (NOAA 2018a). Dive times have been reported between 11 and 33 minutes with an average dive time of 23 minutes (Anderson et al 2006). These whales are usually found in tight groups of 10 to 20 but may be found in larger groups of up to 100 individuals (NOAA 2018a). Longman's beaked whales are thought to feed on cephalopods and dives for up to 33 minutes foraging for food (NOAA 2018a). The full range of functional hearing for beaked whales in the mid-frequency cetacean functional hearing group is estimated to occur between approximately 150 Hz and 160 kHz (Southall et al. 2007).

Distribution. Longman's beaked whales are believed to occur in pelagic waters across the tropical Pacific and Indian Oceans (NOAA 2018a, Pitman et al. 1999). Habitat use of Longman's beaked whales remains relatively unknown. Observations of this species in the Indian Ocean revealed that most sightings were over or adjacent to deep slopes with depths of 250 to > 2,000 m (820 to >6,560 ft; Anderson et al. 2006). They are generally found in warm tropical waters, with most sightings occurring in waters with sea surface temperatures warmer than 26°C (79°F; Anderson et al. 2006; MacLeod et al. 2006). It is unknown whether the Longman's beaked whale participates in a seasonal migration (Jefferson et al. 2008).

Threats. Longman's beaked whales are susceptible to the same potential threats that are generally applicable to all cetacean species known to occur in the Action Area. Significant threats for these whales include entanglement in fishing gear and ocean noise which may disrupt deep-diving cetaceans ability to feed, communicate, and navigate (NOAA 2018a). There are no known threats in the Action Area that are specific to only Longman's beaked whales.

Populations in the Action Area.
Broad Ocean Area: This species is not likely to occur in the BOA of the Action Area. This whale has been observed near the Hawaiian Islands (Carretta et al. 2014). Although sightings are rare, 2010 shipboard surveys resulted in an estimate of 4,571 (CV = 0.65) in the Hawaiian Islands EEZ (Carretta et al. 2014). While this whale is believed to occur in pelagic waters across the tropical Pacific, it is considered rare throughout its range (Pitman et al. 1999).

Vicinity of Illeginni Islet: This species is not known to occur in the vicinity of Illeginni Islet. Longman's beaked whales have not been documented in the deep ocean areas of the RMI (Reeves et al. 1999; Miller 2007).

4.1.11 Pygmy Sperm Whale (*Kogia breviceps*)

Species Description. Pygmy sperm whales are protected under the MMPA and are not listed under the ESA. Pygmy sperm whales reach lengths of 3.8 m (12.5 ft) and weigh up to 450 kg (990 lb; McAlpine 2002). Pygmy sperm whales are considered to be a deep-diving species, based on stomach contents and long dive durations (McAlpine 2002). Pygmy sperm whales are a type of toothed whale, which feeds on mid- to deep-water cephalopods and, less often, on deep-sea fish and crustaceans (Beatson 2007, West et al. 2009). Pygmy sperm whales may occur individually or in small groups of up to about six animals (Caldwell and Caldwell 1989). An auditory brainstem response study completed on a stranded pygmy sperm whale indicated best hearing sensitivity between 90 and 150 kHz (Ridgway and Carder 2001). Functional hearing is estimated to occur between approximately 200 Hz and 180 kHz, placing them among the group of cetaceans that can hear high-frequency sounds (Southall et al. 2007).

Distribution. Pygmy sperm whales occur in tropical, subtropical, and temperate waters worldwide (McAlpine 2002). Based on prey analysis, these whales are thought to inhabit waters along the continental shelf and slope in the epi- and mesopelagic zones and may be found in deeper waters than *K. sima* (McAlpine 2002). The pygmy sperm whale may frequent more temperate habitats than *K. sima,* but little is known about possible seasonality of distribution or migrations for this species (McAlpine 2002).

Threats. Pygmy sperm whales are susceptible to the same potential threats that are generally applicable to all cetacean species known to occur in the Action Area. These whales may be especially susceptible to threats such as entanglement, hunting, vessel strike, ingestion of marine debris, and ocean noise (NOAA 2018a). There are no known threats in the Action Area that are specific to only pygmy sperm whales.

Populations in the Action Area.
Broad Ocean Area: This species is not likely to occur in the BOA of the Action Area. Pygmy sperm whales have rarely been sighted in the Hawaiian Islands EEZ, but two whales were cited during a 2002 shipboard survey (Carretta et al. 2014). While sighting are rare, several stranding or dead pygmy sperm whales have been found in the Hawaiian Islands, at least seven between 2000 and 2014 (Carretta et al. 2014, West et al. 2009). Nothing is known about stock structure for this species (Carretta et al. 2014).

Vicinity of Illeginni Islet: *Kogia* sp. whales have been documented in French Polynesia, Guam, the Northern Mariana Islands, and Samoa, but there are no documented occurrences or abundance estimates in the deep ocean areas of the RMI (Reeves et al. 1999; Miller 2007) and this species is not known to occur in the vicinity of Illeginni Islet.

4.1.12 Dwarf Sperm Whale (*Kogia sima*)

Species Description. Dwarf sperm whales are protected under the MMPA and are not listed under the ESA. Dwarf sperm whales are a type of toothed whale, which generally forage near the seafloor, feeding on cephalopods and, less often, on deep-sea fishes and shrimps (Caldwell and Caldwell 1989). Based on head structure and habitat of the whale's primary prey species, dwarf sperm whales are considered to be a deep-diving species that lives over or near the continental shelf (Caldwell and Caldwell 1989). Dwarf sperm whales have been reported to occur in groups up to about 10 individuals (Caldwell and Caldwell 1989). These whales grow to lengths of 2.7 m (8.9 ft) and weigh up to 272 kg (600 lb; McAlpine 2002). No information on hearing is available for the dwarf sperm whale, but it is assumed to be similar to that of the pygmy sperm whale. Best sensitivity is between 90 and 150 kHz (Ridgway and Carder 2001), and functional hearing is estimated to occur between approximately 200 Hz and 180 kHz, placing them among the group of cetaceans that can hear high-frequency sounds (Southall et al. 2007).

Distribution. Dwarf sperm whales prefer warm tropical, subtropical, and temperate waters worldwide (NOAA 2018a). 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. This species tends to occur over the outer continental shelf but may occur nearer to coastlines in some areas with deep nearshore waters (Caldwell and Caldwell 1989). In a 2013 habitat use study around the main Hawaiian Islands, dwarf sperm whales were observed in all seasons and at their highest rates of detection in slope waters (500 to 2,500 m [1,640 to 8,202 ft] deep; Baird et al. 2013). Since this species is rarely observed, specific information regarding distribution is not available and little is known about possible migrations.

Threats. Dwarf sperm whales are susceptible to the same potential threats that are generally applicable to all cetacean species known to occur in the Action Area. These whales may be particularly susceptible to the threats of entanglement in fishing gear, vessel strike, ingestion of marine debris, and ocean noise (NOAA 2018a). There are no known threats in the Action Area that are specific to only dwarf sperm whales.

Populations in the Action Area.
Broad Ocean Area: This species is not likely to occur in the BOA of the Action Area. While there may be a small resident population of dwarf sperm whales near the Hawaiian Islands, only one individual was observed on both 2002 and 2010 shipboard surveys of the Hawaiian Islands EEZ (Carretta et al. 2014). Since 1985, at least eight dwarf sperm whales have been found stranded on Hawai`i (Carretta et al. 2014). There is no current abundance estimate for the Hawaiian Islands EEZ stock of dwarf sperm whales (Carretta et al. 2014).

Vicinity of Illeginni Islet: This species is not known to occur in the vicinity of Illeginni Islet. *Kogia* sp. whales have been documented in French Polynesia, Guam, and the Northern Mariana Islands, and *K. sima* has confirmed sightings in Samoa (Reeves et al. 1999; Miller 2007). There are no documented occurrences or abundance estimates in the deep ocean areas of the RMI (Reeves et al. 1999; Miller 2007).

4.1.13 Fraser's Dolphin (*Lagenodelphis hosei*)

Species Description. Fraser's dolphins are protected under the MMPA and are not listed under the ESA. This species of dolphin grows to lengths of 2.7 m (8.9 ft) and weighs up to 210 kg (463 lb; Dolar 2002). Fraser's dolphins have been observed in groups of 10 to 100 individuals (NOAA 2018a) and feed on mid-water fishes, squids, and shrimps (Perrin et al. 1994). Available data do not show strong evidence of calving seasonality, but slight peaks may occur in spring and fall (Dolar 2002). While no empirical data on hearing ability for this species are available, functional hearing is estimated to occur between approximately 150 Hz and 160 kHz, placing them among the group of cetaceans that can hear mid-frequency sounds (Southall et al. 2007).

Distribution. Fraser's dolphin is a tropical, subtropical, and warm temperate species, distributed between 30° N and 30° S with a cosmopolitan distribution (Dolar 2002). These dolphins are generally found in waters deeper than 1,000 m (3,300 ft) and can occur near coastlines where the continental shelf is narrow (NOAA 2018a).In the eastern tropical pacific, Fraser's dolphins were observed at least 15 km (8 nm) from the shore and most often 45 to 110 km (24 to 59 nm) from shore in waters 1,500 to 2,500 m (4,900 to 8,200 ft) deep (Dolar 2002) This does not appear to be a migratory species, and little is known about its movements.

Threats. Fraser's dolphins are susceptible to the same potential threats that are generally applicable to all cetacean species known to occur in the Action Area. Major threats for this species include entanglement in fishing gear and hunting (NOAA 2018a). There are no known threats in the Action Area that are specific to only Fraser's dolphins.

Populations in the Action Area.
Broad Ocean Area: This species is not likely to occur in the BOA of the Action Area. These dolphins were first documented within the Hawaiian Islands EEZ on 2002 surveys, and there was one additional sighting of the island of Hawai`i in 2008 (Carretta et al. 2011). Based on the 2002 shipboard surveys, a minimum population estimate of 4,700 Fraser's dolphins was calculated for the Hawaiian Islands EEZ (Carretta et al. 2011). While this species has been recorded near Hawaii, most records of this species are from deep ocean waters south of the BOA including near Kiribati, the Cook Islands, and French Polynesia (Miller 2007).

Vicinity of Illeginni Islet: This species is not known to occur in the vicinity of Illeginni Islet. There are documented occurrences of Fraser's dolphins in the central and western Pacific Ocean in the Cook

Islands, Micronesia, Fiji, French Polynesia, Kiribati, and Nauru. There are no documented occurrences in the deep ocean waters of the RMI (Reeves et al. 1999; Miller 2007).

4.1.14 Humpback Whale (*Megaptera novaeangliae*)

Species Description. Humpback whales are currently divided into 14 distinct population segments (DPSs) recognized by NOAA Fisheries (81 Federal Register [FR] 62259-62320 [October 11, 2016]). The Mexico DPS is listed as threatened under the ESA, four DPSs are listed as endangered under the ESA, and the remaining nine DPSs are not listed under the ESA (81 FR 62259 [October 11, 2016]). In the western and central Pacific, there are three humpback whale DPSs: the Hawai`i DPS (not listed), the Oceania DPS (not listed), and the Western North Pacific DPS (endangered). Humpback whales in the Action Area are likely from the Hawai`i and Oceania DPSs; however, there is the potential for some mixing between the populations throughout the Pacific (Calambokidis et al. 2001). All populations of humpback whale are considered depleted under the MMPA. Humpbacks are baleen whales, which typically feed on krill and small schooling fish in coastal or shelf waters (Clapham 2002). These 14 to 17 m (46 to 56 ft) long whales are generally highly migratory, wintering on calving grounds in the tropics and migrating up to 8,000 km (5,000 miles [mi]) to feeding grounds in mid- or high-latitude waters (Clapham 2002). Humpbacks spend most of their time in the upper 4 m (13 ft) of the water column on the feeding grounds (Dietz et al. 2002). When diving, these whales dive for up to 15 minutes to depths up to 400 m (1,312 ft; Dietz et al. 2002).

In terms of functional hearing capability, humpback whales are considered low-frequency cetaceans, which have hearing ranges from 7 Hz to 22 kHz (Southall et al. 2007). Houser et al. (2001) produced a predicted humpback whale audiogram using a mathematical model based on the internal structure of the ear. Estimated sensitivity was from 700 Hz to 10 kHz, with maximum relative sensitivity between 2 and 6 kHz (Houser et al. 2001).

Distribution. The humpback whale is found throughout the world in all ocean basins (Carretta et al. 2015). These whales are typically found during the summer on 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 (Clapham 2002). 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). On breeding grounds, females with calves occur in significantly shallower waters than other groups of whales, and breeding adults use deeper more offshore waters (Ersts and Rosenbaum 2003; Smultea 1994). Whales that winter in Hawai`i are most likely to migrate to feeding grounds in southeastern Alaska (Calambokidis et al. 2001).

Threats. Humpback whales are susceptible to the same potential threats that are generally applicable to all cetacean species known to occur in the Action Area. As an endangered species, any threats to humpback whale are particularly significant including threats from vessel strike, entanglement in fishing gear, vessel-based harassment, habitat modification, and ocean noise (NOAA 2018a). There are no known threats in the Action Area that are specific to only humpback whales.

Populations in the Action Area.
Broad Ocean Area: NMFS has proposed three DPSs which may occur in the BOA. The Hawai`i DPS consists of whales that breed within the main Hawaiian Islands and seasonally move to feeding grounds in the North Pacific (Bettridge et al. 2015). The Oceania DPS consists of whales that breed/winter in the south Pacific islands and are believed to migrate to undescribed Antarctic feeding areas (Bettridge et al. 2015). It is possible that the Action Area may include whales of the West North Pacific DPS which

feed/summer in the north Pacific off the Russian coast and breed near Okinawa, the Philippines, and possibly breeding ground further south (Bettridge et al. 2015). Humpback whales have been detected during surveys of the Mariana Islands to the west of the Action Area (Department of the Navy 2014).

Recent studies (2008) of the North Pacific basin resulted in total population estimates of 21,808 (CV=0.04) for all humpback whales feeding in the north Pacific (Bettridge et al. 2015). The Hawai`i DPS portion of this area was estimated to number 10,000 individuals in 2008 (Calambokidis et al. 2008) and may be closer to 11,788 to 12,462 individuals (Bettridge et al. 2015). Peak occurrence around the Hawaiian Islands is from late February through early April (Carretta et al. 2015; Mobley et al. 2000). During the fall and winter, primary occurrence is expected in the Hawaiian Islands, from the coast to 93 km (50 nm) offshore (Mobley 2004; Mobley et al. 2000). Based on 2008 studies of the north Pacific basin, photo identification, and capture-recapture analysis, 1,000 whales are estimated to be in the West North Pacific DPS (Bettridge et al. 2015).

Oceania humpback whale populations are estimated to be 3,827 (CV=0.12) individuals; however, the population appears to be subdivided with relatively little known about the movements and feeding areas for these whales (Bettridge et al. 2015).

Vicinity of Illeginni Islet: While there are historical records of humpback whale sightings in the RMI (Reeves et al. 1999; Miller 2007), this species is not known to occur in the vicinity of Illeginni Islet. There is no available information on the abundance of humpback whales in the deep ocean areas of the RMI.

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

Species Description. Blainville's beaked whales are protected under the MMPA and are not listed under the ESA. Blainville's beaked whales reach 4.7 m (15 ft) long (Pitman 2002) and weigh 816 to 1,043 kg (1,800 to 2,300 lb; NOAA 2018a). As in other beaked whale species, Blainville's beaked whales appear to feed on squid and some fish in deep waters (Pitman 2002). Little is known about the movements or behavior or beaked whales. These whales are known to dive from 20 to over 45 minutes at a time (Pitman 2002). An audiogram of a Blainville's beaked whale revealed the range of best hearing was 40 to 50 kHz for this species with thresholds as low at 48.9 dB (Pacini et al. 2011). Beaked whales are part of the mid-frequency cetaceans functional hearing group with an estimated auditory bandwidth of 150 Hz to 160 kHz (Southall et al. 2007).

Distribution. Blainville's beaked whales are one of the most widely distributed of the distinctive toothed whales in the *Mesoplodon* genus and are found throughout the world in tropical, sub-tropical, and warm temperate waters (MacLeod et al. 2006). These whales are known to occur along the California coast, Hawai`i, and in the Eastern Tropical Pacific and some research indicates they are found mostly offshore in deeper waters (MacLeod and Mitchell 2006). In other studies, these whales have been found to prefer water depths of 200 to 1,000 m (656 to 3,280 ft; IUCN 2015). In a 2013 habitat use study around the main Hawaiian Islands, Blainville's beaked whales had a bimodal pattern of sighting by water depth with peak encounter rates between 500 and 1,500 m (1,640-4,921 ft) deep and between 3,500 and 4,000 m (11,483-13,123 ft) deep (Baird et al. 2013). It is unknown whether this species makes specific migrations.

Threats. Blainville's beaked whales are susceptible to the same potential threats that are generally applicable to all cetacean species known to occur in the Action Area. There are no known threats in the Action Area that are specific to only Blainville's beaked whales.

Populations in the Action Area.
Broad Ocean Area: This species has the potential to occur in the BOA of the Action Area. Recent studies of Blainville's beaked whales near the main Hawaiian Islands suggest there are insular and offshore populations (Baird et al. 2013). Movements of individuals from insular populations indicate this population remains in nearshore waters off Oahu with average distance from shore of 21.6 km (11.7 nm; Baird et al. 2013). While the status and distribution of offshore populations remains relatively unknown, one whale, presumed to be from the offshore population, moved far from shore (over 900 km [486 nm]) to the west of the main islands (Carretta et al. 2014). Shipboard line-transect surveys of the Hawaiian Islands EEZ in 2010 resulted in an abundance estimate of 2,338 (CV = 1.13) whales of this species (Carretta et al. 2014). Unidentified *Mesoplodon* spp. whales have been detected on January/February 2010 surveys conducted between the Hawaiian Islands and Guam via Wake Island (PISFC 2010a).

Vicinity of Illeginni Islet: This species is not known to occur in the vicinity of Illeginni Islet. There are documented occurrences of Blainville's beaked whales in the island chains in the central and western Pacific, but there are no documented occurrences or abundance estimates in the RMI (Reeves et al. 1999; Miller 2007).

4.1.16 Killer Whale (*Orcinus orca*)

Species Description. Killer whales are considered depleted under the MMPA and potential populations in the Action Area are not listed under the ESA. These highly social animals occur most commonly in groups from 2 to 15 animals (NOAA 2018a). These whales feed on a variety of prey including marine mammals, fish, cephalopods, sea turtles, and sea birds (Ford 2009). Killer whales forage either individually, in small groups, or cooperatively depending on the whale population and prey type (Ford 2009). Killer whales may calve in any moth of the year, but most births are in October–March (Ford 2009). Recent behavioral audiograms of killer whales indicated hearing between 600 Hz and 114 kHz with best hearing at 34 kHz with a 49 dB re 1 μPa threshold (Branstetter et al. 2017). Another study using behavioral and auditory evoked potential audiograms of two captive killer whales indicate that they can hear sounds ranging from 1 to 120 kHz (best hearing ranging from 18 to 42 kHz), with most sensitivity at 20 kHz and a detection threshold of 36 dB re 1 μPa (Szymanski et al. 1999). The full range of functional hearing is estimated to occur between approximately 150 Hz and 160 kHz, placing them among the group of cetaceans that can hear mid-frequency sounds (Southall et al. 2007).

Distribution. Killer whales are found in all oceans of the world and are most common in coastal temperate waters (Ford 2009). Eight killer whale stocks are recognized in the Pacific US EEZ, with only the Hawaiian stock occurring in the Action Area (Carretta et al. 2014). Although considered one species, killer whales are broken down into different "ecotypes" that are distinguished by distinct social and foraging behaviors and other ecological traits (Ford 2009). In the North Pacific, these distinct forms are known as resident, transient, and offshore ecotypes (NOAA 2018a). These whales are considered rare in Hawaiian waters, with only two sightings in 2002 surveys and one sighting during 2010 surveys of the Hawaiian Islands EEZ (Carretta et al. 2014).

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 (Dahlheim and Heyning 1999). Although killer whales are also found in tropical waters and the open ocean, they are most abundant in coastal habitats at high latitudes (Dahlheim and Heyning 1999). In most areas of their range, killer whales do not show movement patterns that would be classified as traditional migrations. However, some populations exhibit seasonal shifts in density, likely in response to prey availability (Ford 2009).

Threats. Killer whales are susceptible to the same potential threats that are generally applicable to all cetacean species known to occur in the Action Area. Major threats for this species include food depletion from overfishing and habitat loss, contaminants, oil spills, disturbance from vessels, and ocean noise (NOAA 2018a). There are no known threats in the Action Area that are specific to only killer whales.

Populations in the Action Area.
Broad Ocean Area: Offshore killer whales are known to inhabit both the western and eastern temperate Pacific and likely have a continuous distribution across the North Pacific (Dahlheim et al. 2008). Although killer whales apparently prefer cooler waters, they have been observed in Hawaiian waters (Barlow 2006, Baird et al. 2013). These sightings are extremely infrequent and typically occur during winter or spring, suggesting no resident population in Hawai`i (Mobley et al. 2001, Baird et al. 2013). A 2010 shipboard line-transect survey of the Hawaiian Islands EEZ resulted in an abundance estimate of 101 (CV = 1.0) whales (Carretta et al. 2014).

Vicinity of Illeginni Islet: There have been documented occurrences of Killer whales in the western Pacific, as well as one documented occurrence in the RMI (Reeves et al. 1999; Miller 2007). Three killer whales were sighted 4.73 km (2.94 mi) off of the coast of South Pass in April of 2007 (USAF 2007). There is no available information on the abundance of killer whales in the RMI, and this species is not known to occur in the vicinity of Illeginni Islet.

4.1.17 Melon-headed Whale (*Peponocephala electra*)

Species Description. Melon-headed whale are protected under the MMPA and are not listed under the ESA. Melon-headed whales reach lengths of 2.7 m (8.9 ft; Perryman 2002). These whales are often found in large groups, sometimes in mixed aggregations with Fraser's dolphins or spinner dolphins (Perryman 2002). Most of the fish and squid families eaten by this species of toothed whale consist of mid-water forms found in waters up to 1,500 m (4,920 ft) deep, suggesting that feeding takes place deep in the water column (Jefferson and Barros 1997). Melon-headed whales feed primarily on squid but have also been known to eat small fish and shrimp (Perryman 2002). Whether calving is significantly seasonal is unclear, but some evidence suggests a peak in July and August (Jefferson and Barros 1997). While no empirical data on hearing ability for this species are available, functional hearing is estimated to occur between approximately 150 Hz and 160 kHz, placing them among the group of cetaceans that can hear mid-frequency sounds (Southall et al. 2007).

Distribution. Melon-headed whales are found worldwide in tropical and subtropical waters with extralimital observations at higher latitudes with incursion of warm water currents (Perryman 2002). Melon-headed whales are most often found in offshore, deep waters but sometimes move close to shore in areas with deeper water (Perryman 2002). Brownell et al. (2009) found that melon-headed whales near oceanic islands rested near shore during the day and fed in deeper waters at night. This species is not known to migrate. In a 2013 habitat use study around the main Hawaiian Islands (Baird et al. 2013), melon-headed whales were observed throughout the year and in waters with a wide range of depths.

Threats. Melon-headed whales are susceptible to the same potential threats that are generally applicable to all cetacean species known to occur in the Action Area. Major threats to melon-headed whales include entanglement in fishing gear, pollution, and ocean noise (NOAA 2018a). There are no known threats in the Action Area that are specific to only melon-headed whales.

Populations in the Action Area.
Broad Ocean Area: This species is likely to occur in the BOA of the Action Area. For the MMPA stock assessment reports, there are two Pacific management stocks, both within the Hawaiian Islands EEZ (Carretta et al. 2014). The Kohala resident sock includes animals in less than 2,500 m (8,202 ft) deep waters off Kohala peninsula and the west coast of Hawai`i Island (Carretta et al. 2014). The main Hawaiian Islands stock occurs throughout the Hawaiian Islands EEZ and moves offshore (Carretta et al. 2014, Baird et al. 2013); however, data on abundance and distribution are largely lacking. A 2002 to 2009 mark-recapture analysis resulted in an estimate of 5,794 (CV = 0.20) individuals in the Hawaiian Islands stock (Carretta et al. 2014). Melon-headed whales were also detected on surveys conducted between the Hawaiian Islands and Guam via Wake Island (PISFC 2010a; PISFC 2010b). One individual was sighted on a January/February 2010 cruise (PISFC 2010a), and three individuals were sighted on the April/May 2010 cruise along with additional acoustic detections (PISFC 2010b). These whales have also been documented near many islands in the central Pacific south of the Action Area (Miller 2007).

Vicinity of Illeginni Islet: This species is not known to occur in the vicinity of Illeginni Islet. There have been documented occurrences of melon-headed whales in the central and western Pacific and in the deep ocean areas of the RMI (Reeves et al. 1999; Miller 2007). There was a documented sighting of five whales 4.8 km (3 mi) off the coast of Kwajalein on October 23, 2005 (USAF 2007). There are no abundance estimates available for the RMI.

Mass strandings (those of three or more animals) of melon-headed whales were reviewed in Brownell et al. (2006). Of the 29 documented mass strandings of this species, 5 have occurred in the Pacific islands, and one of these was in the Marshall Islands in 1990, at Kwajalein Atoll (others in Hilo, Hawai`i in 1841; Palmyra Atoll sometime before 1964; Malékoula Island, Vanuatu in 1972; and Hanalei Bay, Kauai in 2004). This indicates that some individuals of this species are at least occasionally in these waters. The events at Palmyra and Kwajalein atolls were unusual because the stranding occurred inside the atoll’s lagoon, and only a small number of animals were involved.

4.1.18 Sperm Whale (*Physeter macrocephalus*)

Species Description. Sperm whales have been endangered since 1970 under the precursor to the ESA and are listed as depleted under the MMPA. Sperm whales are largest of the toothed whales, reaching lengths of 16 m (52 ft; Whitehead 2002). Females inhabit deeper waters (greater than 1,000 m [3,280 ft]) at latitudes below 40° and are highly social (Whitehead 2002). Female sperm whales spend most of their lives in family units of about 12 females with communal defense and care of young (Whitehead 2002). Male sperm whales may be found at higher latitudes but are more likely to be observed in productive waters such as those along the edges of continental shelves (Whitehead 2002). Sperm whales are deep divers, feeding primarily on squid and other cephalopods as well as on bottom-dwelling fish and invertebrates (Whitehead 2002, Davis et al. 2007). These large whales spend most of their time in deep waters where their prey are found (NOAA 2018a).

Direct measures of sperm whale hearing showed responses to pulses ranging from 2.5 to 60 kHz and highest sensitivity to frequencies between 5 and 20 kHz (Ridgway and Carder 2001). Reactions to anthropogenic (man-made) sounds can provide indirect evidence of hearing capability, and several studies have noted changes seen in sperm whale behavior in conjunction with these sounds. For example, sperm whales have been observed to frequently stop echolocating in the presence of underwater pulses made by echosounders and submarine sonar (Watkins and Schevill 1977). In the Caribbean, Watkins et al. (1985) observed that sperm whales exposed to 3.25 to 8.4 kHz pulses (presumed to be from submarine sonar) interrupted their activities and left the area. Similar reactions were observed from artificial noise generated by banging on a boat hull (Watkins et al. 1985). André et al. (1997) reported that foraging whales exposed to a 10 kHz pulsed signal did not ultimately exhibit any general avoidance reactions: when resting at the surface in a compact group, sperm whales initially reacted strongly, and then ignored the signal completely. Thode et al. (2007) observed that the acoustic signal from a fishing vessel's rapidly spinning propeller (110 dB re 1 μPa^2 between 250 Hz and 1.0 kHz) interrupted sperm whale acoustic activity and resulted in the animals converging on the vessel. Sperm whales are in the mid-frequency cetacean functional hearing group with an estimated full range of functional hearing between approximately 150 Hz and 160 kHz (Southall et al. 2007).

Distribution. Sperm whales are divided into three stocks in the Pacific: (1) the Hawaiian stock, (2) the California, Oregon, and Washington stock, and (3) the Alaskan stock. Sperm whales show a strong preference for deep waters (Rice 1989; Whitehead 2003). Adult females are generally found far from land at latitudes less than 40° and in waters 1,000 m (3,280 ft) or deeper (Whitehead 2002). Although adult males are more likely to be observed in deeper, productive waters (Whitehead 2002), in some areas adult males frequent waters with bottom depths less than 100 m (330 ft) and as shallow as 40 m (130 ft; Romero et al. 2001). In a habitat use study around the main Hawaiian Islands, sperm whales were observed most frequently in waters greater than 3,000 m (9,842 ft) deep (Baird et al. 2013). Female sperm whales and young are typically found far from land (Whitehead 2002). Typically, sperm whale concentrations occur in areas with high biomass of deep water prey which are generally near drop-offs such as the edges of continental shelves (Whitehead 2002). Sperm whales are somewhat migratory depending on their location, gender, and prey abundance (NOAA 2018a). General shifts occur during the summer for feeding and breeding, while in some tropical areas, sperm whales appear to be largely resident (Rice 1989; Whitehead 2003; Whitehead et al. 2008).

Threats. Sperm whales are susceptible to the same potential threats that are generally applicable to all cetacean species known to occur in the Action Area. Major threats to sperm whales include vessel strike, entanglement in fishing gear, ocean noise, ingestion of marine debris, contaminants, and habitat and food availability changes resulting from climate change (NOAA 2018a). There are no known threats in the Action Area that are specific to only sperm whales.

Populations in the Action Area.
Broad Ocean Area: The sperm whale's range occurs throughout the BOA. This species is typically found in the temperate and tropical waters of the Pacific (Whitehead 2002). Sperm whales are found year-round in Hawaiian waters and are most commonly observed in waters greater than 3,000 m (9,842 ft) deep (Baird et al. 2013). The current best available abundance estimate for the Hawaiian stock of sperm whales is 3,354 (CV = 0.34) based on 2010 shipboard line-transect surveys of the Hawaiian Islands EEZ (Carretta et al. 2014). Sperm whales have also been detected on surveys conducted between the Hawaiian Islands and Guam via Wake Island (PISFC 2010a; PISFC 2010b). Three sperm whales were sighted on a January/February 2010 cruise (PISFC 2010a) and four were sighted on an April/May 2010 cruise along with additional acoustic detections (PISFC 2010b).

Vicinity of Illeginni Islet: There have been documented occurrences of sperm whales in the Illeginni Islet area of Kwajalein Atoll. In 2000, a pod of approximately 12 sperm whales was seen a few miles southeast of Illeginni Islet. On August 5, 2006, two whales were sighted between Legan and Illeginni Islet (USAF 2007). In April 2009, an estimated four sperm whales were sighted a few miles southeast of Illeginni (USAKA 2009).

Sperm whales have been documented in many of the island chains in the central and western Pacific, including the RMI (Reeves et al. 1999; Miller 2007). An acoustic study performed off of the coast of Kwajalein Atoll in 2007 reported almost continuous detection of sperm whale sounds in the 26, 44, and 46 days of the study. This study concluded that sperm whales are highly active in the area during March, May, and September (Nosal 2011). In April 2009, four individuals with calves were reported in the open ocean area surrounding Kwajalein Atoll (9° 00.27' N; 167° 01.30' W), 4.8 km (3 mi) off Legan Islet. These whales were observed breaching, lobtailing, diving, and resting (USAKA 2009). More reported sightings are listed below:

- On December 4, 2006, one individual was sighted 3.2 to 4.8 km (2 to 3 mi) off the coast of Carlos;
- On December 11, 2006, two individuals were sighted off the coast of Gea Pass;
- On May 3, 2007, one whale was sighted off the coast of Ninni;
- On May 3, 2007, five individuals were sighted off Gehh Island; this included two different sightings, the first sighting documented two individuals, whereas the second sighting documented three individuals (USAF 2007);
- Four sperm whales were sighted by a cruise conducted by Shimada et al. (2003) in the RMI between 7° N and 19° N and 156° E and 169° E.

There is no available information on the abundance of sperm whales in the RMI.

4.1.19 False Killer Whale (*Pseudorca crassidens*)

Species Description. False killer whales are protected under the MMPA and are not listed under the ESA throughout most of their range. However, the local Hawai`i insular stock (considered resident to the islands) is listed as endangered under the ESA and depleted under the MMPA. False killer whales are a type of toothed whale which feed primarily on oceanic cephalopods and fish but have been known to feed on smaller dolphins (Baird 2002a). Reaching lengths of up to 6 m (20 ft), these whales usually travel in groups of 20 to 100 individuals and are considered extremely social (Baird 2002a). Females may give birth year-round with peak calving in late winter (Baird 2002a). Behavioral audiograms of three captive false killer whales have been conducted; range of best hearing spanned from 16 to 64 kHz. The full range of functional hearing for this species is estimated to occur between approximately 150 Hz and 160 kHz, placing them in the mid-frequency cetaceans functional hearing group (Southall et al. 2007).

Distribution. False killer whales prefer tropical to temperate waters that are deeper than 1,000 m (3,300 ft; NOAA 2018a). There are five recognized Pacific Islands management stocks of false killer whales, three of which may occur near the Action Area: the Hawai`i insular stock which includes whales within 72 km (39 nm) of the main Hawaiian Islands; the Northwestern Hawaiian stock which includes animals inhabiting waters within 93 km (50 nm) of the northwest Hawaiian Islands; and the Hawai`i pelagic stock which includes whales in waters greater than 11 km (6 nm) from the main Hawaiian Islands and throughout the northwest Hawaiian Islands (Carretta et al. 2016). False killer whales are not considered a migratory species, although seasonal shifts in density likely occur for some populations.

Threats. In addition to the potential threats that are generally applicable to all cetacean species, various factors have drawn attention to the fact that there is a high risk of extinction for the Hawai`i insular population of false killer whales (Oleson et al. 2010). These include the small population size of this stock, evidence of decline of the local Hawai`i stock, and several factors that are expected to adversely impact the population in the future, mainly longline fisheries in the Hawaiian Islands. Due to recent evidence of a serious decline in this 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 within NOAA on January 19, 2010, as required by the MMPA. The Take Reduction Team did a status review that was published in August 2010 (Oleson et al. 2010). A final rule on the take reduction plan was issued by NOAA in November 2012 which focused on regulatory measures for longline fishing gear, longline prohibited areas, and training in marine mammal handling and release (77 FR 71259 [November 29, 2012]).

Populations in the Action Area.
Broad Ocean Area: Only the Hawai`i pelagic stock has the potential to occur in the BOA of the Action Area. This species is known to occur in deep ocean areas near the Hawaiian Islands and throughout the tropical Pacific. The Hawai`i pelagic stock was estimated to be 1,540 (CV = 0.66) whales outside of 11 km (6 nm) of the main Hawaiian Islands based on 2010 shipboard line-transect surveys (Carretta et al. 2016). This estimate may be biased high as false killer whales have demonstrated some vessel attraction (Carretta et al. 2016). Little is known about false killer whale distributions in the BOA. This species has the potential to occur in the BOA of the Action Area; however, densities of false killer whales are likely very low. Few false killer whales have been detected on surveys conducted between the Hawaiian Islands and Guam via Wake Island (PISFC 2010a; PISFC 2010b). One individual was sighted on a January/February 2010 cruise (PISFC 2010a), and one was sighted on an April/May 2010 cruise along with additional acoustic detections (PISFC 2010b). False killer whales have been recorded near islands south of the BOA of the Action Area including French Polynesia and Samoa but there are no confirmed records near the islands closest to the Action Area (Miller 2007).

Vicinity of Illeginni Islet: This species is not known to occur in the vicinity of Illeginni Islet. In the central and western Pacific, false killer whales have been documented off the islands of American Samoa, Fiji, and French Polynesia, but their range is not thought to extend into the RMI (Reeves et al. 1999; Miller 2007).

4.1.20 Pantropical Spotted Dolphin (*Stenella attenuata*)

Species Description. Pantropical spotted dolphins are listed as depleted under the MMPA and are not listed under the ESA. Adults of this species are 166 to 2.57 m (5.45 to 8.43 ft) long and weigh up to 119 kg (262 lb; Perrin 2002b). Pantropical spotted dolphins prey on near-surface fish, squid, and crustaceans and on some benthic species (Perrin 2002b). Results from various tracking and food habit studies suggest that pantropical spotted dolphins in the eastern tropical Pacific and off Hawai`i feed primarily at night on surface and mid-water species (Baird et al. 2001; Robertson and Chivers 1997). Pantropical spotted dolphins are known to breed year-round and occur in groups of several hundred to a thousand animals (NOAA 2018a).

Studying the ear anatomy of the pantropical spotted dolphin, Ketten (1992, 1997) found that they have ear anatomy similar to other delphinids. While no empirical data on hearing ability for this species are available, functional hearing is estimated to occur between approximately 150 Hz and 160 kHz, placing them in the mid-frequency cetacean functional hearing group (Southall et al. 2007).

Distribution. The pantropical spotted dolphin is distributed worldwide in offshore tropical and subtropical waters between about 40° N and 40° S latitudes (Perrin 2002b). It is found mostly in deeper offshore waters but does approach the coast in some areas (Perrin 2001). In the eastern tropical Pacific, pantropical spotted dolphins are most abundant in waters with a sharp thermocline at depths of 50 m (164 ft) or less (Perrin 2002b). Based on known habitat preferences, occurrence is expected in waters 90 to 300 m (300 to 1,000 ft) deep during the day and possibly in deeper waters at night when foraging for prey (NOAA 2018a). This species is common in the Hawaiian Islands and surrounding offshore areas. For the MMPA there are four Pacific management stocks within the Hawaiian Islands EEZ: the Oahu stock, the 4-Island stock (dolphins near Maui, Molokai, Lanai, and Kahoolawe), the Hawai`i Island stock, and the Hawai`i pelagic stock (Carretta et al. 2014). Although pantropical spotted dolphins do not migrate, extensive movements are known in the eastern tropical Pacific (Scott and Chivers 2009). Five pantropical spotted dolphins were also sighted on shipboard surveys conducted between the Hawaiian Islands and Guam via Wake Island in April/May 2010 (PISFC 2010b).

Threats. Pantropical spotted dolphins are susceptible to the same potential threats that are generally applicable to all cetacean species known to occur in the Action Area. Major threats for this species include entanglement in fishing gear, interactions with people, and hunting (NOAA 2018a). There are no known threats in the Action Area that are specific to only pantropical spotted dolphins.

Populations in the Action Area.
Broad Ocean Area: Pantropical spotted dolphins are frequently sighed in pelagic waters. Pantropical spotted dolphins were among the most commonly observed odontocetes in waters greater than 3,000 m (9,843 ft) deep in a 2013 habitat use study around the main Hawaiian Islands (Baird et al. 2013) Population estimates for the separate stocks of this species are not available; however, 2010 shipboard line-transect surveys resulted in an abundance estimate of 15,917 (CV = 0.40) spotted dolphins within the pelagic stock area of the Hawaiian Islands EEZ (Carretta et al. 2014).

Vicinity of Illeginni Islet: While there are documented occurrences of the pantropical spotted dolphin in the central and western Pacific Ocean in American Samoa, Cook Islands, Fiji, French Polynesia, and Kiribati and in the deep ocean areas of the RMI (Reeves et al. 1999; Miller 2007), this species is not known to occur in the vicinity of Illeginni Islet.

4.1.21 Striped Dolphin (*Stenella coeruleoalba*)

Species Description. Striped dolphins are protected under the MMPA and are not listed under the ESA. These small dolphins reach lengths of 2.4 m (7.9 ft) in the western Pacific and are often observed in schools of 10 to several hundred individuals (Archer 2002). Striped dolphins often feed on fish and squid in open sea or sea bottom zones beyond the continental shelf where they dive from 200 to 700 m (656 to 2,297 ft) for prey (Archer 2002). Striped dolphins give birth to a single calf during summer or autumn (NOAA 2018a). Kastelein et al. (2003), using standard psychoacoustic techniques, measured a striped dolphin’s range of most sensitive hearing to be 29 to 123 kHz, with maximum sensitivity occurring at 64 kHz with a signal strength of 42 dB re 1μPa. Striped dolphins are in the mid-frequency functional hearing group for cetaceans which are estimated to have a full range of functional hearing between 150 Hz and 160 kHz (Southall et al. 2007).

Distribution. Striped dolphins are found primarily in warm equatorial and tropical waters but appear to prefer waters with more variable conditions with upwelling and large seasonal changes in temperature structure (Au and Perryman 1985). This abundant and widespread species is generally restricted to pelagic 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).

Threats. Striped dolphins are susceptible to the same potential threats that are generally applicable to all cetacean species known to occur in the Action Area. Major threats for striped dolphins include entanglement in fishing gear, disease (specifically morbillivirus), and hunting (NOAA 2018a). There are no known threats in the Action Area that are specific to only striped dolphins.

Populations in the Action Area.
Broad Ocean Area: These dolphins are abundant and widespread in oceanic regions. In a habitat use study around the main Hawaiian Islands, striped dolphins were among the most commonly observed cetaceans and were found at their highest rates in very deep water (> 3,000 m [9,843 ft]; Baird et al 2013). While striped dolphin sightings are infrequent in nearshore waters, 2010 shipboard surveys of the Hawaiian Islands EEZ resulted in 29 sightings and an abundance estimate of 20,650 (CV = 0.36) dolphins (Carretta et al. 2014). One striped dolphin was sighted on a shipboard survey conducted between the Hawaiian Islands and Guam via Wake Island in January/February 2010 (PISFC 2010a).

Vicinity of Illeginni Islet: While the primary range of the striped dolphin includes the deep ocean waters around USAKA in the RMI, this species is not known to occur in the vicinity of Illeginni Islet. In the central and western Pacific Ocean, there are documented occurrences in Micronesia and the RMI (Crawford 1993; Reeves et al. 1999; Miller 2007).

4.1.22 Spinner Dolphin (*Stenella longirostris*)

Species Description. Spinner dolphins are considered depleted under the MMPA and are not listed under the ESA. Adult spinner dolphins range in length from 1.29 to 2.35 m (4.23 to 7.71 ft; Perrin and Gilpatrick 1994). Spinner dolphins feed primarily on small mid-water fishes, squid, and shrimp, and they dive to at least 200 to 300 m (655 to 985 ft; Perrin and Gilpatrick 1994). Spinner dolphins have variable school size and are commonly found in schools with pantropical spotted dolphins (Perrin and Gilpatrick 1994). Mating and calving occur throughout the year but may be more seasonal in some regions (Perrin and Gilpatrick 1994). Dolphins in the genus *Stenella* are considered part of the mid-frequency cetaceans function hearing group which has an estimated auditory bandwidth of 150 Hz to 160 kHz (Southall et al. 2007).

Distribution. Spinner dolphins occur throughout tropical and subtropical waters in both hemispheres (Perrin and Gilpatrick 1994). Spinner dolphins occur in large numbers in oceanic habitats but some populations in the eastern Pacific and in tropical waters occur in coastal habitats as well (Perrin and Gilpatrick 1994). In most areas, including the eastern tropical Pacific, spinner dolphins are found primarily in deep ocean waters (Perrin and Gilpatrick 1994). However, spinner dolphins around Hawai`i have a more coastal distribution, using inshore waters, islands, or banks (Perrin and Gilpatrick 1994). In the central and western Pacific, spinner dolphins are island-associated and expected to occur in shallow water resting areas (about 50 m [164 ft] deep or less) throughout the middle of the day, moving into deep waters offshore during the night to feed (Carretta et al. 2013). Island-associated stocks have an offshore boundary of 18.5 km (10 nm) from shore based on observations that no dolphins have been seen farther than 18.5 km (10 nm) from shore (Carretta et al. 2013). Spinner dolphins are reported to have strong seasonal shifts in habitats with year-to-year variation in habitat use (Perrin and Gilpatrick 1994).

Threats. Spinner dolphins are susceptible to the same potential threats that are generally applicable to all cetacean species known to occur in the Action Area. Major threats for spinner dolphins include entanglement in fishing gear, illegal feeding and harassment, habitat degradation, ocean noise, disease, and vessel strike (NOAA 2018a). There are no known threats in the Action Area that are specific to only spinner dolphins.

Populations in the Action Area.
Broad Ocean Area: This species may occur in the BOA of the Action Area. While one individual of this species was sighted on an April/May 2010 shipboard survey conducted between the Hawaiian Islands and Guam via Wake Island (PISFC 2010b), this species is typically a nearshore species and these sightings may have been in a nearshore area. This species also occurs in nearshore waters of the Hawaiian Islands (Carretta et al. 2013) where the species has been recorded throughout the year with most sightings in waters less than 500 m (1,640 ft) deep (Baird et al. 2013). The Pacific stock assessment report for the Hawaiian stock of spinner dolphins reports a minimum population estimate of 585 individuals for this species (Carretta et al. 2016).

Vicinity of Illeginni Islet: Spinner dolphins are known to occur in the central and western Pacific Ocean in American Samoa, Cook Islands, Micronesia, Fiji, French Polynesia, Guam, Kiribati, New Caledonia, Niue, CNMI, Papua New Guinea, Samoa, Solomon Islands, Tonga, Tuvalu, and Vanuatu. There are multiple surface sightings of spinner dolphins recorded at USAKA (Table 4-3). On July 27, 2006, a large group of spinner dolphins was sighted near the helipad on Illeginni Islet (Table 4-3). Because of the number of sightings of spinner dolphins in the area, as well as in the deep ocean waters around USAKA, it is likely that they are relatively common around Illeginni Islet.

Table 4-3
Documented Occurrences of Spinner Dolphins at USAKA

Date	Location	Number of Dolphins
October 23, 2005	Near Carlson	50
June 21, 2006	Shark Pit	6
July 27, 2006	Near Helipad on Illeginni Islet	100
February 26, 2007	Outside SAR, along the reef	100
February 23, 2007	Oceanside, southwest of Kwajalein Atoll	36
March 1, 2007	Between Legan and Lone Palm	100
May 3, 2007	South Pass	60
May 3, 2007	Oceanside, off Kwajalein Golf Course	50
May 3, 2007	Oceanside, off Big Bustard	30
May 11, 2007	Lagoon Meck	30
May 15, 2007	Near Parrothead Buoys 1-3	10
June 1, 2007	West Lagoon	5

Source: USAF 2007

4.1.23 Rough-toothed Dolphin (*Steno bredanensis)*

Species Description. Rough-toothed dolphins are protected under the MMPA and are not listed under the ESA. Natural history information for this small dolphin species is largely lacking; however, they may feed on squid and fish (NOAA 2018a, Jefferson 2002). These dolphins usually occur in tight-knit groups of 10 to 20 but may be found in groups up to 300 and often associate with other dolphin species (Jefferson 2002). Little is known about the breeding biology, movements, or diving behavior in this species (Jefferson 2002). Auditory evoked potential measurements showed that rough-toothed dolphins can hear from 5 to 80 kHz (80 kHz was the upper limit tested) and probably higher frequencies (Cook et al. 2006). These dolphins are in the mid-frequency cetaceans functional hearing group with an estimated auditory bandwidth between 150 Hz and 160 kHz (Southall et al. 2007).

Distribution. The rough-toothed dolphin is regarded as an offshore species that prefers oceanic tropical and subtropical waters (Jefferson 2002), but it can occur in waters of variable bottom depth. In French Polynesia, rough-toothed dolphins were observed over a wide area but were more commonly found inshore, 1.8 to 5.5 km (1 to 3 nm) from a barrier reef and in water depths between 1,000 and 2,000 m (3,280 to 6,568 ft, Gannier and West 2005). In a 2013 habitat use study around the main Hawaiian Islands, rough-toothed dolphins were observed in all seasons and at their highest rates of detection in very deep [>3,000 m (>9,842 ft) deep] waters (Baird et al. 2013). There is no evidence that the rough-toothed dolphin migrates. Little is known about the stock structure for this species in the Pacific (Carretta et al. 2014) and no information regarding routes, seasons, or resighting rates in Pacific areas is available.

Threats. Rough-toothed dolphins are susceptible to the same potential threats that are generally applicable to all cetacean species known to occur in the Action Area. Major threats for this species include entanglement in fishing gear, hunting, and ocean noise (NOAA 2018a). There are no known threats in the Action Area that are specific to only rough-toothed dolphins.

Populations in the Action Area.
Broad Ocean Area: This species has the potential to occur in the BOA of the Action Area. Little is known about rough-toothed common dolphins in the deep waters of the BOA, but this predominantly offshore species has been observed near islands throughout the tropical central Pacific including Kiribati, French Polynesia, and Samoa (Miller 2007). This species also occurs in nearshore waters of the Hawaiian Islands (Carretta et al. 2014, Baird et al. 2013). The Hawaiian Islands EEZ was surveyed in 2010 via shipboard line-transect surveys which resulted in an abundance estimate of 6,288 (CV = 0.39) dolphins in this area (Carretta et al. 2014). This species has also been observed during surveys of the Mariana Islands to the west of the Action Area (Department of the Navy 2014).

Vicinity of Illeginni Islet: This species is not known to occur in the vicinity of Illeginni Islet. The rough-toothed dolphin has been documented in the central and western Pacific Ocean in American Samoa, French Polynesia, and Kiribati, but there are no documented occurrences in the deep ocean areas of the RMI (Reeves et al. 1999; Miller 2007).

4.1.24 Bottlenose Dolphin (*Tursiops truncatus*)

Species Description. Bottlenose dolphins are protected under the MMPA and are not listed under the ESA. The Western North Atlantic Coastal stock is considered depleted under the MMPA while other stocks are not (NOAA 2018a). Bottlenose dolphins are commonly found in groups of 2-15 individuals but larger groups of up to 1,000 have been recorded (Wells and Scott 2002). Group size and feeding habits may differ between coastal and pelagic populations with smaller group sizes in inshore populations (Wells and Scott 2002). Bottlenose dolphins feed primarily on bottom dwelling fish and squid, but some surface dwelling or pelagic fish are also consumed (Wells and Scott 2002). Bottlenose dolphins have been known to give birth in all seasons; however, calving occurs primarily in winter (Wells and Scott 2002).

Audiograms of the bottlenose dolphins shows that best sensitivity occurs near 50 kHz at a detection threshold level of about 45 dB re 1 µPa with a range of underwater hearing from 10 to 150 kHz (Houser and Finneran 2006). Below the maximum sensitivity, thresholds increased (indicating less sensitivity) continuously up to a level of 137 dB re 1 μPa at 75 Hz; above 50 kHz, thresholds increased slowly up to a level of 55 dB re 1 μPa at 100 kHz, then increased rapidly above this to about 135 dB re 1 μPa at 150 kHz. Bottlenose dolphin hearing sensitivity varies with age and sex, with a progressive loss of high frequency hearing with age, and with males exhibiting an earlier onset of hearing loss than females (Houser and Finneran 2006). Bottlenose dolphins are in the mid-frequency cetaceans functional hearing group which has an estimated auditory bandwidth of 150 Hz and 160 kHz (Southall et al. 2007).

Distribution. The bottlenose dolphin has a worldwide distribution ranging from latitudes of 45° N to 45° S (Wells and Scott 2002). Bottlenose dolphins are found both in coastal and offshore waters with surface temperatures between 10 and 32°C (Wells and Scott 2002). Some populations of bottlenose dolphin appear to be migratory, others have year-round home ranges, and some a combination of long-range movements and local residency (Wells and Scott 2002). In the Hawaiian Islands stock complex, over 99% of the bottlenose dolphins belonging to the insular populations were documented in waters of 1,000 m (3,280 ft) or less (Carretta et al. 2014). In a habitat use study around the main Hawaiian Islands, Baird et al. (2013) recorded bottlenose dolphins throughout the year with most observations in waters less than 500 m (1,640 ft) deep. A Hawai`i pelagic stock is recognized, although little is known about their distribution.

Threats. Bottlenose dolphins are susceptible to the same potential threats that are generally applicable to all cetacean species known to occur in the Action Area. Major threats for bottlenose dolphins include entanglement in fishing gear, habitat destruction and degradation, biotoxins linked to algal blooms, and illegal feeding and harassment (NOAA 2018a). There are no known threats in the Action Area that are specific to only bottlenose dolphins.

Populations in the Action Area.
Broad Ocean Area: This species has the potential to occur in the BOA of the Action Area. There are coastal stocks of bottlenose dolphins around many central Pacific islands including the Hawaiian Islands (Carretta et al. 2014). Individuals in the coastal stocks are not likely to be in the BOA as they are primarily found within 500 m (1,640 ft) of the shoreline (Carretta et al. 2018). Little is known about the density and distribution of the pelagic stock of this species in the central and eastern Pacific; however, they are known to occur offshore of Hawai`i (Carretta et al. 2014). The Hawaiian Islands EEZ pelagic stock was estimated at 5,950 (CV = 0.59) dolphins based on 2010 shipboard line-transect surveys (Carretta et al. 2014). This species has also been observed during surveys of the Mariana Islands to the west of the Action Area (Department of the Navy 2014) as well as near Kiribati, French Polynesia, and Samoa (Miller 2007).

Vicinity of Illeginni Islet: While there are documented occurrences of the bottlenose dolphin in the central and western Pacific in American Samoa, Micronesia, Fiji, French Polynesia, and Kiribati and in the deep ocean areas of the RMI (Reeves et al. 1999; Miller 2007), this species is not known to occur in the vicinity of Illeginni Islet.

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

Species Description. Cuvier's beaked whales are protected under the MMPA and are not listed under the ESA in the Action Area. Life history characteristics of Cuvier's beaked whale are not well known. Cuvier's beaked whales are known to be deep divers. Tagged whales have been recorded diving up to 2,992 m (9,816 ft) and for up to 137.5 minutes (Schorr et al. 2014). Cuvier's beaked whales forage between about 600 m (1,968 ft) and almost 3,000 m (9,842 ft) deep (West et al. 2017) using echolocation to find prey (Valdivia 2017). This species is a type of toothed whale, which primarily feeds on cephalopods in deep waters but also feeds on fish and crustaceans (West et al. 2017). Breeding and calving for this species may occur year-round but peaks in the spring (Valdivia 2017). While no direct measurements of hearing in Cuvier's beaked whales are known, simulation studies based on whale morphology estimated hearing *for Z. cavirostris* in the range of 2 to 100 kHz with the point of best hearing at 48 kHz (Escobar 2016). Cuvier's beaked whales are in the mid-frequency cetaceans functional hearing group which is estimated to have hearing in the range of 150 Hz and 160 kHz (Southall et al. 2007).

Distribution. Cuvier's beaked whales have an extensive range that includes all oceans, from the tropics to the polar waters of both hemispheres (Valdivia 2017). Similar to other beaked whale species, this oceanic species generally occurs in waters past the edge of the continental shelf. They are generally sighted in waters with a bottom depth greater than 200 m (655 ft) and are frequently recorded in waters with bottom depths greater than 1,000 m (3,280 ft; Falcone et al. 2009). Little is known about potential migration in this species.

Threats. Cuvier's beaked whales are susceptible to the same potential threats that are generally applicable to all cetacean species known to occur in the Action Area. Major threats for this species include entanglement in fishing gear, vessel strike, and ocean noise (NOAA 2018a). There are no known threats in the Action Area that are specific to only Cuvier's beaked whales.

Populations in the Action Area.
Broad Ocean Area: This species is known to occur near the Hawaiian Islands. In 2010, summer/fall shipboard surveys resulted in 22 sightings of Cuvier's beaked whales and an abundance estimate of 1,941 (CV = 0.70) for the Hawaiian Islands EEZ. Cuvier's beaked whales have also been observed during surveys of the Mariana Islands to the west of the Action Area (Department of the Navy 2014). This species has the potential to occur in the BOA of the Action Area.

Vicinity of Illeginni Islet: This species is not known to occur in the vicinity of Illeginni Islet. There are documented occurrences of Cuvier's beaked whales in American Samoa, the Cook Islands, and French Polynesia, but there are no documented sightings or abundance estimates in the RMI (Reeves et al. 1999; Miller 2007).

4.1.26 Hawaiian Monk Seal (*Neomonachus schauinslandi*)

Species Description. The Hawaiian monk seal was listed as endangered under the ESA throughout its range in 1976 (41 FR 51611 [23 November 1976]) and is listed as depleted under the MMPA. This seal is one of only two remaining monk seal species and grows to 2.3 m (7.5 ft) and weighs up to 273 kg (600 lb; NMFS 2011). Monk seals feed on a variety of prey including fish, cephalopods, and crustaceans, primarily at depths between 50 and 300 m (164 to 984 ft) deep (NMFS 2011). While monk seals generally forage in these shoreline areas, they are known to hunt deeper than 500 m (1,640 ft; NMFS 2007). Most monk seals give birth between February and August; however, births have been recorded year-round (NMFS 2011).

Distribution. Hawaiian monk seals live in subtropical waters surrounding atolls, islands, and submerged offshore reefs or banks. These seals spend the majority of their lives at sea (NMFS 2011). When the seals do haul-out for resting, breeding, or pupping, they do so on sand, corals, and volcanic rock but prefer protected sandy beaches for pupping (NMFS 2011). The entire range of the Hawaiian monk seal is within US waters on and near the Hawaiian Islands. The majority of seals breed and pup on the NWHI; however, seals have given birth on all of the major islands of Hawai`i (NMFS 2011). One seal tracked by satellite was observed traveling at least 700 km (378 nm) south-southwest of the main Hawaiian Islands (PacIOOS 2018).

Threats. Hawaiian monk seals are among the most endangered marine mammals in the world. Reasons for their decline and listing include; low juvenile survival due to food limitations, mortality from entanglement in marine debris, predation by sharks, human disturbance of mothers and pups, mortality and injury from recreational fishing, haul-out and pupping habitat loss due to erosion, and disease outbreaks (NMFS 2007). Despite recent recovery actions and a recovery plan completed in 1983 and in 2007, the seal population has continued to decline over the past two decades (NMFS 2007).

Critical Habitat. Critical habitat was designated for the Hawaiian monk seal in 1986 with revisions in 1988 and 2015 (80 FR 50925 [August 21, 2015]). In the revised rule, critical habitat includes terrestrial areas used for pupping, nursing, and haul-out as well as marine habitat within 10 m (33 ft) of the seafloor out to the 200 m (656 ft) depth contour (80 FR 50925 [August 21, 2015]). This critical habitat includes areas around the main Hawaiian Islands and the NWHI. Critical habitat has been designated on Kauai; however, no Hawaiian monk seal critical habitat was designated immediately adjacent to PMRF. Hawaiian monk seal critical habitat does not occur in the portion of the Action Area that will be subject to direct contact effects (Figure 4-1). The stage 1 booster drop zone does not overlap any Hawaiian monk seal critical habitat. No adverse effects to Hawaiian monk seal critical habitat are anticipated from the Proposed FE-2 Action.

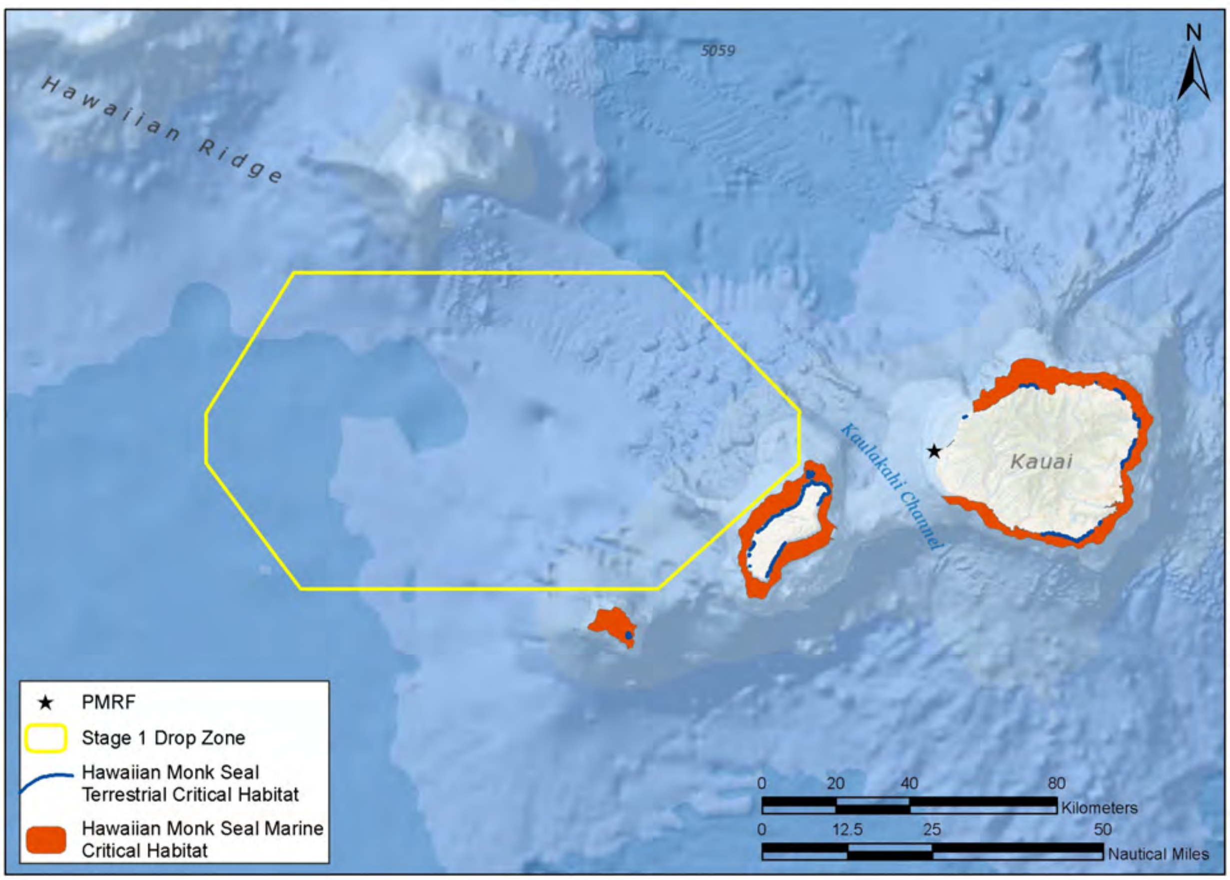

Figure 4-1. Hawaiian Monk Seal Critical Habitat in Relation to the FE-2 Action Area near the Hawaiian Islands.

Populations in the Action Area.
Broad Ocean Area: This species is known to occur on and near the Hawaiian Islands including Kauai. The current population of this species is approximately 1,200 individuals (NMFS 2007). Monk seals spend the majority of their time close to shore in waters less than 90 m (300 ft) deep, and the majority of seals are found in the northern Hawaiian Islands. Seals are known to forage in offshore areas up to 700 km (378 nm) from the Hawaiian Islands and in waters up to 500 m (1,640 ft) deep (NMFS 2011).

Vicinity of Illeginni Islet: This species does not occur in the vicinity of Illeginni Islet.

4.2 Birds

One species of seabird that requires consultation has the potential to occur in the Action Area, Newell's shearwater (*Puffinus auricularis newelli*). No consultation bird species are known to nest in the Action Area. Since seabirds may have wide ranging foraging and non-nesting season distributions, it is possible that Newell's shearwaters may forage or rest at sea in the BOA portion of the Action Area.

4.2.1 Newell's Shearwater / `A`o (*Puffinus auricularis newelli*)

Species Description. The Newell's shearwater is listed as a threatened species under the ESA throughout its range. This species was listed in 1975 (40 FR 17590 [April 21, 1975]), and a recovery plan for Newell's shearwater was approved in February 1983 (USFWS 2011b). This is a medium sized shearwater (30 to 36 cm [12 to 14 in]) with a sharply hooked bill and claws adapted for burrow excavation and climbing. Newell's shearwaters nest in the Hawaiian Islands; however, little is known about foraging and other at-sea behavior (USFWS 2011b). Shearwaters mostly feed on small marine animals such as fish and squid by diving or while floating on the water surface.

Distribution. Newell's shearwaters breed only in the southeastern Hawaiian Islands where they nest in burrows on steep forested mountain slopes (Pyle and Pyle 2009). Adults return to Hawai`i to breed in April and depart in early fall (Pyle and Pyle 2009). Little is known about their winter range or about their pelagic foraging distribution, although birds are known to consistently fly out to sea southwest of Kauai for foraging (J. Burger personal communication 2017). Newell's shearwaters have been primarily recorded in the tropical Pacific between 9-12° N and 160-120° W. However, these birds have been observed and collected at Guam, Saipan, Wake Island, Johnston Atoll, and American Samoa (Pyle and Pyle 2009). While little is known about the abundance and distribution of these birds in the open ocean, it is likely that the distribution and abundance of the pelagic food supply determines the marine distribution of seabirds.

Threats. Since the early 1990's, Newell's shearwater populations have experienced sharp declines (USFWS 2011b). Analysis of detection data trends on Kauai indicated an overall decline of 50–70% between 1993 and 2001 (USFWS 2011b). Primary threats to Newell's shearwater are terrestrial in nature and include nest predation by introduced terrestrial mammals, decrease in nesting habitat suitability due to invasive plant species, and artificially lighting which disorients fledgling birds (USFWS 2011b). Studies on Kauai have documented abandonment of three of eight nesting colonies since the mid 1990's (USFWS 2011b). Although new lights on Kauai are shielded, there is still significant mortality of fledged shearwaters (2–10% or more or fledglings) due to fallout (USFWS 2011b). Fallout occurs when fledgling seabirds making their first flights to the ocean from their natal colony are disoriented by artificial light sources and/or strike artificial structures.

Populations in the Action Area.
Broad Ocean Area: The Newell's shearwater forages in BOA and offshore waters near breeding grounds where it feeds primarily on squid. While little is known about these birds in the BOA, researchers have recorded Newell's shearwaters in low numbers in offshore waters near Hawai`i (Pyle and Pyle, 2009). These researchers observed the highest numbers of shearwaters in the spring and within 370 km (200 nm) of Kauai (Pyle and Pyle 2009). Newell's shearwaters are known to consistently fly southwest of Kauai on foraging flights (J. Burger personal communication 2017); however, their primary foraging locations and abundance in this area are unknown. Tracking of several birds immediately after fledging revealed preliminary data that birds flew southwest of Kauai approximately 2,500 km (4,351 mi) to putative wintering grounds (A. Raine personal communication). It is likely that the distribution and abundance of food supply determines the marine distribution of shearwaters as it does with other seabirds.

Vicinity of Illeginni Islet: This species is not known to occur in the vicinity of Illeginni Islet.

4.3 Sea Turtles

Five species of sea turtle: green, hawksbill, leatherback, loggerhead, and olive ridley, all of which are listed under the ESA (Table 4-1), occur in the Action Area. All five may occur in the BOA outside of the RMI (Table 4-4). Much of the sea turtle research in the BOA has been conducted on the beaches and nearshore waters of Hawai`i; thus, much of the data documenting the species' occurrence in the BOA is limited to that region. Of the five species, only the green turtle and hawksbill turtle are known to occur in the waters of the RMI. Green turtles are more common, while hawksbills are considered rare or scarce (Maison et al. 2010). Only green and hawksbill turtles are known to occur in the vicinity of Illeginni Islet. None of these species has designated critical habitat in the Action Area.

Table 4-4
Sea Turtle Presence in the Broad Ocean Area (BOA) and Near Illeginni Islet.

Common Name	Scientific Name	ESA Listing Status	Protection Status	Likelihood of Occurrence: In the BOA	Likelihood of Occurrence: Near Illeginni Islet
Loggerhead turtle	*Caretta caretta*	E	UES	P	U
Green turtle	*Chelonia mydas*	E, T	UES	L	L
Leatherback turtle	*Dermochelys coriacea*	E	UES	L	U
Hawksbill turtle	*Eretmochelys imbricata*	E	UES	L	P
Olive ridley turtle	*Lepidochelys olivacea*	E, T	UES	P	U

Sources: See species descriptions in Section 4.3.
E: Endangered, T: Threatened, D: Depleted, UES: UES protection (USASMDC/ARSTRAT 2018 Section 3-4.5.1)
L-Likely; P – Potential; U – Unlikely

Summary of Threats to Sea Turtles. Though each of the sea turtle species in the Action Area has unique life history characteristics and preferred habitat, many environmental factors are common among all species. Bycatch in commercial fisheries, ship strikes, and marine debris are primary threats to sea turtles in the BOA (Lutcavage et al. 1997). One comprehensive study estimated that worldwide, 447,000 turtles are killed each year from bycatch in commercial fisheries (Wallace et al. 2010). Precise data are lacking for sea turtle deaths directly caused by ship strikes; however, live and dead turtles are often found with deep cuts and fractures indicative of a collision with a boat hull or propeller (Hazel et al. 2007; Lutcavage et al. 1997). Marine debris can also be a problem for sea turtles through entanglement or ingestion. Sea turtles can mistake debris for prey; one study found 37% of dead leatherbacks to have ingested various types of plastic (Mrosovsky et al. 2009). In another study of loggerhead turtles in the north Atlantic, 83% (n = 24) of juvenile turtles were found to have ingested plastic marine debris (Pham et al. 2017). Other marine debris, including derelict fishing gear and cargo nets, can entangle and drown turtles in all life stages.

Aquatic degradation issues, such as poor water quality and invasive species, can alter ecosystems, limit food availability, and decrease survival rates. Environmental degradation can also increase susceptibility to diseases, such as fibropapillomatosis, a debilitating tumor-forming disease that primarily affects green turtles (Santos et al. 2010). Fibropapillomatosis causes tumor-like growths (fibropapillomas), resulting in reduced vision, disorientation, blindness, physical obstruction to swimming and feeding, and increased susceptibility to parasites (NMFS and USFWS 1998b; Santos et al. 2010).

Global climate change, with predictions of increased ocean and air temperatures and sea level rise, may also negatively impact turtles in all life stages, from egg to adult (Griffin et al. 2007; Poloczanska et al. 2009). Effects include embryo death caused by high nest temperatures, skewed sex ratios due to increased sand temperature, decreased growth rates, loss of nesting habitat to beach erosion, coastal habitat degradation (e.g., increased water temperature and disease), as well as, alteration of the marine food web, which can decrease the amount of prey species (Poloczanska et al 2009). A recent study of green sea turtles foraging in the Great Barrier Reef found that warmer beaches are producing primarily female turtles (87–99% of turtles; Jensen et al. 2018). Bjorndal et al. (2017) found declines in the growth rate of green turtles after 1999 and cite previous studies that revealed similar declines in hawksbill and loggerhead turtles starting in 1997. Ecological shifts due to warming waters, changing weather patterns, and anthropogenic activities may be among the stressors contributing to decreased growth rates in sea turtles (Bjorndal et al. 2017).

In the RMI, sea turtles are an important part of Marshallese culture; they are featured in many myths, legends, and traditions, where they are revered as sacred animals. Eating turtle meat and eggs on special occasions remains a prominent part of the culture. Presently, despite national and international protection as endangered species, marine turtles remain prestigious and a highly desired source of food in the RMI (Kabua and Edwards 2010). Turtles have long been a food source in the RMI, though the level of exploitation is unknown. Direct harvest of eggs and nesting adult females from beaches, as well as direct hunting of turtles in foraging areas, continues in many areas. Anecdotal information from RMI residents suggests a decline in the green turtle population, possibly of up to 50% in the last 10 years (McCoy 2004). The harvest of sea turtles in the RMI is regulated by the RMI Marine Resources Act, which sets minimum size limits for greens (86 cm [34 in] carapace length) and hawksbills (69 cm [27 in] carapace length) and closed seasons from June 1 to August 31 and December 1 to January 31. Egg collecting and take of turtles while they are onshore is prohibited (Kabua and Edwards 2010). The Marshall Islands Marine Resources Authority manages marine resources in the RMI, which does not participate in CITES.

Sea turtles' long life expectancy and site fidelity may make them vulnerable to chronic exposure to marine contaminants (Woodrom Rudrud et al. 2007). Sea turtles may also be vulnerable to the bioaccumulation of heavy metals in their tissues (Sakai et al. 2000). At this time, the amount of contaminants in the marine environment at USAKA has not been measured, and sea turtles in the RMI have not been tested for heavy metal levels in blood or tissues. Damage to coral reefs can reduce foraging habitat for hawksbill turtles, and damage to seagrass beds and declines in seagrass distribution can reduce nearshore foraging habitat for green turtles in the RMI (NMFS and USFWS 2007c).

Sea Turtle Hearing. The range of maximum sensitivity for sea turtles appears to be 200 to 800 Hz (Lenhardt 1994). Hearing below 80 Hz is less sensitive but still potentially usable to the turtle (Lenhardt 1994). Ridgway et al. (1969) concluded that green turtles have a useful hearing span of 60 to 1,000 Hz, but they hear best from 200 Hz up to 700 Hz, with sensitivity falling off considerably below 400 Hz. Auditory evoked potentials of hatchling leatherback turtles revealed a hearing range between 50 and 1,200 Hz in water, with a maximum sensitivity between 100 and 400 Hz at 84 dB_{RMS} re 1µPa (Dow Piniak et al. 2012). For loggerhead turtles, auditory evoked potentials audiograms revealed hearing in the range of 100 to 1,131 Hz with best sensitivity between 200 and 400 Hz at 110 dB re 1 µPa (Martin et al. 2012). Because sea turtle anatomy is similar among species, other sea turtle species are thought to have the same sensitivity ranges.

4.3.1 Loggerhead Turtle (*Caretta caretta*)

Species Description. The loggerhead is protected under the UES and is listed under the ESA. Nine DPSs of the loggerhead turtle have been identified. Two of these populations may occur in the Action Area: the North Pacific DPS and the South Pacific DPS. Turtles in the Action Area are likely part of the North Pacific DPS based on their known distributions and migration patterns. In September 2011, the North Pacific and South Pacific populations were listed as endangered under the ESA (76 FR 58868 [September 22, 2011]). Loggerheads are primarily carnivorous. Juveniles and adults forage in coastal habitats, where they feed on a variety of bottom-dwelling animals, such as crabs, shrimp, sea urchins, sponges, and fish (Bjorndal 1997). During migration through the open ocean, they may eat jellyfish, mollusks, flying fish, and squid.

Distribution. The loggerhead turtle is found in temperate to tropical regions of the Atlantic, Pacific, and Indian oceans and in the Mediterranean Sea (NMFS and USFWS 2007d). Hatchlings and early juveniles live in the open ocean before moving to nearshore foraging habitats close to their birth area (Musick and Limpus 1997). They may use the same nearshore habitat as juveniles or may move among different areas before settling in an adult coastal foraging habitat (Godley et al. 2003). Migratory routes can be in relatively shallow coastal waters or can involve crossing deep 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 inter-nesting and overwintering habitat.

In the Pacific, loggerhead turtles are known to occur in upwelling zones along the Pacific coast of North America and occasionally in open ocean of the central North Pacific, but the only known nesting concentrations for this species occur in Japan and Australia (Bowen et al. 1995). Mitochondrial DNA analysis of loggerheads feeding off Baja California and some caught in North Pacific drift-nets indicates that most individuals come from Japanese nesting populations (Bowen et al. 1995).

Threats. North Pacific Ocean loggerheads have declined 50–90% in recent decades. This decline is the result of fishery bycatch from the coastal fisheries off Baja California that affect juvenile foraging populations and from other fisheries that likely affect loggerheads in the South China Sea and the North Pacific Ocean (NMFS and USFWS 2007e). Loggerhead turtles are susceptible to the same potential threats that are generally applicable to all turtle species known to occur in the Action Area. There are no known threats in the Action Area that are specific to only loggerhead turtles.

Populations in the Action Area.
Broad Ocean Area: While incidental catches of loggerheads in the Hawai`i-based longline fishery indicate their use of these waters for migrations and development (Polovina et al. 2000). Loggerheads appear to use the entire North Pacific Ocean during development. There is evidence that the North Pacific Ocean loggerhead 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 and migrate through the North Pacific Gyre current as they move between North American developmental habitats and nesting beaches in Japan (Polovina et al. 2000, Polovina et al. 2004). Loggerheads have primarily been recorded using productive North Pacific open ocean habitats from 28-40° N where sea temperatures are 15-25°C (Polovina et al. 2004). The occurrence of loggerhead turtles in the BOA waters southwest of Hawai`i is believed to be rare.

Vicinity of Illeginni Islet: This species is not known to occur in the vicinity of Illeginni Islet.

4.3.2 Green Turtle (*Chelonia mydas*)

Species Description. The green turtle was listed as threatened 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 2007b). In March 2015, the USFWS and NMFS proposed 11 DPSs globally for the green turtle (Seminoff et al. 2015) the rule was finalized in April 2016 (USFWS and NOAA 2016). Green turtles in the Action Area may belong to one of two DPSs: the Central North Pacific DPS (which includes the Hawaiian Islands) or the Central West Pacific DPS (which includes the RMI). The Central North Pacific DPS of green turtles is listed as threatened, while the Central West Pacific DPS is listed as Endangered (USFWS and NOAA 2016). Green turtles are mostly herbivorous. They feed primarily on sea grass and algae, at or near the surface in both coastal and open ocean areas (Mortimer 1995). Green turtles spend the majority of their lives in coastal foraging grounds; however, oceanic habitats are used by oceanic-stage juveniles, migrating adults, and occasional foraging adults (NMFS and USFWS 2007b).

Distribution. The green turtle is found in tropical and subtropical coastal and open ocean waters of the Atlantic, Pacific, and Indian oceans, generally between 30° N and 30° S (Hirth 1997). There are 6 major nesting populations in the Pacific Ocean and at least 166 smaller nesting sites (NMFS and USFWS 2007b; Seminoff et al. 2015; Maison et al. 2010). Green turtle habitat varies by life stage. Hatchlings live in the open ocean for several years. Once reaching the juvenile stage, they congregate in shallower coastal feeding areas (Carr 1987; Bresette et al. 2006). Green turtles spend most of their lives as late juveniles and adults in relatively shallow waters (3 to 10 m [10 to 33 ft] with abundant seagrass and algae, near reefs or rocky areas used for resting (NMFS and USFWS 2007b). They are highly migratory; both males and females typically migrate seasonally along coastal routes from breeding areas to feeding grounds, while some populations migrate across entire ocean basins (NMFS and USFWS 2007b). There is no evidence of gene flow or migration between the Central North Pacific DPS and the Central West Pacific DPS. Wide expanses of open ocean separate these two population segments, and there is no evidence that breeding adults move between these adjacent populations (Seminoff et al. 2015).

Threats. The green sea turtle was listed under the ESA due to excessive commercial harvest, a lack of effective protection, evidence of declining numbers, and habitat degradation and loss (NMFS and USFWS 2007b). The harvest of eggs and nesting females for food remains a primary threat to the species across the Pacific Ocean (Maison et al. 2010). In addition, green sea turtles are susceptible to the same potential threats that are generally applicable to all turtle species known to occur in the Action Area. There are no known threats in the Action Area that are specific to only green sea turtles.

Populations in the Action Area.
Broad Ocean Area: Green turtles are found in inshore waters around the main Hawaiian Islands and the Northwest Hawaiian Islands, where reefs, their preferred habitats for feeding and resting, are most abundant (Seminoff et al. 2015). The largest green turtle nesting concentration in the central Pacific occurs at French Frigate Shoals in the NWHI (NMFS and USFWS 2007b). The current best abundance estimate for the Central North Pacific DPS of green turtles is 3,846 nesters with an increasing abundance trend (NOAA 2018a). More than 90% of the Hawaiian green turtle population nests at French Frigate Shoals and mainly migrate to coastal areas of the Main Hawaiian Islands to feed (NOAA 2018a). In a 2008 study, Dutton et al. found that 99.9% of sampled green turtles foraging across the Hawaiian Archipelago were genetically assigned to the French Frigate Shoals nesting population. Studies suggest that after hatching, juveniles are pelagic, and hatchlings from the French Frigate Shoals nesting population spend their oceanic years in the north central Pacific and feeding grounds around the Hawaiian Archipelago and Johnston Atoll (Dutton et al. 2008). North Pacific longline fisheries data and genetic analysis found about 57% of green turtle captures in the North Pacific come from nesting areas in Mexico, and 43% are from Hawaiian nesting populations (Gilman et al. 2007). Green turtle migratory routes in the BOA are unknown.

Vicinity of Illeginni Islet: Green turtles occur in deep ocean waters of the RMI as hatchlings, pelagic juveniles, and migrating adults, but little is known of their distribution in these waters. As described above, green turtles forage in nearshore habitats. Depths in this region of the RMI generally range between 2,000 and 5,000 m (6,560 and 16,400 ft; Hein et al. 1999). Shallow lagoons throughout RMI, especially areas with seagrass (*Halophila gaudichaudii*) beds, provide significant areas of potential foraging habitat for green turtles (Eckert 1993). Historical sightings of this species have occurred in these nearshore areas.

Green turtles nest on several atolls, but USAKA is not a significant nesting area. Based on available information, Seminoff et al. (2015) estimated 300 nesting females in the RMI out of a total of 6,500 nesting females in the Central West Pacific DPS (4.6% of known breeding population). In a 2008 survey of USAKA, suitable nesting habitat (relatively open sandy beaches and seaward margins of herbaceous strand above tidal influence) for sea turtles was identified (Figure 4-2), and these areas were thoroughly surveyed on foot for nesting pits and tracks. These nesting and haulout habitats were reevaluated during the 2010 inventory and were determined to still be suitable habitat; however, no sea turtle nests or nesting activity have been observed on Illeginni in over 20 years. Sea turtles have been observed hauling out and nesting at the northeastern portion of Kwajalein Islet, including the lagoon side at Emon Beach and the sand berm on the ocean side, approximately east of Emon Beach. However, no sea turtles were observed during the 2008 survey. Three sea turtle nests (species unidentified) were found at Kwajalein Islet in September and October 2010, on a beach on the east-facing shore across the street from the high school (USAFGSC and USASMDC/ARSTRAT 2015). The nests were excavated after the eggs hatched, and the numbers of hatched and unhatched eggs were estimated as follows:

- Nest excavated on September 2, 2010: approximately 56 hatched eggs and 7 unhatched eggs.
- Nest excavated on September 25, 2010: approximately 65 to 70 hatched eggs and 1 unhatched egg.
- Nest excavated on October 28, 2010: approximately 93 hatched eggs, 3 partially hatched eggs, and 1 unhatched egg.

Figure 4-2. Suitable Sea Turtle Nesting Habitat (red) on Illeginni Islet, Kwajalein Atoll.

Successful sea turtle nesting on Eniwetak was confirmed by video recordings of turtle hatchlings entering the ocean at the islet in May 2011 (Aljure 2016). Successful nesting was also observed on Kwajalein Islet in January 2015 when hatchlings were found and returned to the beach or ocean (Aljure 2016). Observations of potential turtle haul-outs within Kwajalein Atoll include a lagoon-side observation at Legan in May 2013, one at Eniwetak in March 2014, two haul-outs on the ocean-side of Kwajalein Islet in 2014, and two at Eniwetak in December 2014 (Aljure 2016).

The most significant green turtle nesting assemblage in RMI is in Bikar Atoll, in the northeastern corner of RMI. Nesting here occurs from May to November, peaking from June to September. NMFS and USFWS (1998b) estimated 100 to 500 green turtles might nest annually in RMI.

Known green sea turtle activity in the vicinity of Illeginni Islet is limited to the following individual sightings:

- An adult green turtle was seen in nearshore waters on the ocean side of Illeginni in 1996 (USFWS and NMFS 2002);
- An adult turtle of unknown species was documented in the 2006 inventory;
- Four green sea turtles were observed near Illeginni in the 2010 inventory;
- In 2012, one green sea turtle was observed off a lagoon patch reef adjacent to Illeginni Islet;
- An adult green sea turtle was observed during the 2014 inventory in a dense area of seagrass (*Halophila minor*) in Illeginni Harbor; and
- Sea turtle nest pits (unidentified species) were last found on Illeginni Islet in 1996, on the northern tip of the islet. No nesting was observed in surveys completed in 1998, 2000, 2002, 2004, 2006, 2008, or 2010, although suitable sea turtle nesting habitat was observed (USFWS 2011a, USFWS and NMFS 2012). Suitable nesting habitat appears northwest and east of the helipad on the lagoon side of Illeginni Islet (Figure 4-2; USFWS and NMFS 2012).

The reported observations listed above were made during single-day surveys that were part of biennial resource inventories. These surveys were very limited in scope and effort, lasting for only a few hours and usually done by three people. The low number of sightings near Illeginni Islet may be attributed to the low level of effort expended to observe sea turtles there.

4.3.3 Leatherback Turtle (*Dermochelys coriacea*)

Species Description. The leatherback turtle is listed as endangered as a single global population under the ESA. While preliminary genetic data may support separation into DPSs (NMFS and USFWS 2007d; TEWG 2007), this species is not currently separated into DPSs under the ESA. Most stocks in the Pacific Ocean are faring poorly, where nesting populations have declined more than 80% in the past (TEWG 2007). Leatherback turtles are distinguished from other sea turtles in the Action Area by their leathery shell and large size. Adults can reach 2 m (6.5 ft) in length (NMFS and USFWS 1992). Leatherback turtles feed mostly on jellyfish; however, they are also known to consume crustaceans, vertebrates, and plants (NMFS and USFWS 2013c).

Distribution. Leatherback turtles are found in tropical to temperate regions of the Atlantic, Pacific, and Indian oceans (NMFS and USFWS 1992) and nest from 38° N to 34° S latitude (NMFS and USFWS 2013c). Leatherbacks are able to tolerate colder water than other species and have the most extensive range of all sea turtles, from approximately 71° N to 47° S (NMFS and USFWS 2013c). Leatherbacks occur mostly in the open ocean and are only occasionally found in coastal areas. While hatchlings distribution is likely determined by passive drift, juveniles begin to actively swim toward warmer latitudes during winter and higher latitudes during spring (NMFS and USFWS 2013c). Leatherback abundance is highest in highly productive areas where geographic features, currents, and upwelling concentrate prey (NMFS and USFWS 2013c). In the Pacific, important seasonal foraging areas have been identified in seven ecoregions including the East Australian Current Extension, the Kuroshio Extension, the equatorial Eastern Pacific, and the California Current Extension (NMFS and USFWS 2013c). In the Pacific Ocean, leatherbacks nest year-round on nesting beaches in the tropical western Pacific including Papua New Guinea, Indonesia, and the Solomon Islands (NMFS and USFWS 2013c). In the eastern Pacific, the main nesting beaches are found in Mexico and Costa Rica (NMFS and USFWS 2013c). Turtles migrate from these nesting grounds to foraging grounds in the north Pacific (NMFS and USFWS 2013c). These turtles travel great distances during migration and have been known to travel over 11,000 km (5,940 nm) during migration that might take up to a year (NMFS and USFWS 2013c).

Threats. There have been drastic declines in many leatherback turtle populations. Eastern Pacific leatherback nesting populations in Mexico and Costa Rica have shown a greater than 90% decline over the last three generations (NOAA 2018a). In the western Pacific, similar declines (78%) have been observed in the largest nesting population in Indonesia (NOAA 2018a). Causes for the decline in leatherback turtles include natural and anthropogenic impacts to nesting beaches and marine habitat and continued egg collection around the world (NMFS and USFWS 2013c). Leatherback turtles are also susceptible to the same potential threats that are generally applicable to all turtle species known to occur in the Action Area. There are no known threats in the Action Area that are specific to only leatherback turtles.

Populations in the Action Area.
Broad Ocean Area: Satellite tracking studies and occasional incidental captures of leatherbacks in the Hawaiian longline fishery indicate that deep ocean waters are the preferred habitat of leatherback turtles in the central Pacific Ocean. Leatherbacks from nesting beaches in the Indo-Pacific region have been

tracked migrating thousands of kilometers through the North Pacific 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% originated from the western Pacific Ocean nesting beaches (NMFS and USFWS 2007d). The remaining 6% 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.

Because leatherback distribution is so closely associated with jellyfish aggregations, changes in jellyfish distribution or abundance may be a threat to this species in the open ocean. Incidental capture in longline and coastal gillnet fisheries in the Pacific has caused a substantial number of leatherback deaths, likely because leatherbacks dive to depths targeted by longline fishermen and are less maneuverable than other sea turtle species (NMFS and USFWS 2007d).

Vicinity of Illeginni Islet: This species is not known to occur in the vicinity of Illeginni Islet.

4.3.4 Hawksbill Turtle (*Eretmochelys imbricata*)

Species Description. The hawksbill turtle is listed as endangered as a single global population under the ESA (NMFS and USFWS 1998a). Genetic data may support the separation of hawksbill populations under the DPS policy, which has been applied to other sea turtle species (NMFS and USFWS 2007c; NMFS and USFWS 2013b). This would lead to specific management plans for each designated population. Hawksbills feed primarily on sponges, which comprise as much as 95% of their diet (Meylan 1988) but are more omnivorous in the Indo-Pacific including algae, soft corals, and other invertebrate species (NMFS and USFWS 2013b). The shape of their mouth allows hawksbills to reach into crevices of coral reefs to find sponges and other invertebrates.

Distribution. The hawksbill turtle is the most tropical of the world’s sea turtles, rarely occurring higher than 30° N or lower than 30° S in the Atlantic, Pacific, and Indian ocean. Abundance estimates are largely based on annual reproductive effort for sea turtle species (NMFS and USFWS 2013b). 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 1998a). Surveys of know nesting assemblages in the western and central Pacific Ocean indicate mostly decreasing population trends over the past 20 years (NMFS and USFWS 2013b).

Hatchlings and small juveniles live in the open ocean where water depths are greater than 200 m (656 ft) before settling into nearshore habitats as older juveniles (NMFS and USFWS 2013b). Larger juvenile and adult hawksbills prefer neritic, coral reef habitats (NMFS and USFWS 2013b). Reefs provide shelter for resting hawksbills day and night, and they are known to repeatedly visit the same resting areas (NMFS and USFWS 2013b). Hawksbills are thought to have a mixed migration strategy where some turtles remain close to their rookery and other are highly mobile, traveling thousands of kilometers to foraging areas (NMFS and USFWS 2013b).

Threats. The hawksbill shell has been prized for centuries by artisans and their patrons for jewelry and other adornments. Despite being prohibited under the CITES, trade remains a critical threat to the species (NMFS and USFWS 2007c). Hawksbill turtles are susceptible to the same potential threats that are generally applicable to all turtle species known to occur in the Action Area. There are no known threats in the Action Area that are specific to only hawksbill turtles. In the Pacific, the most significant source of death for hawksbill turtles is direct take of turtles for trade of their shell. These takes generally occur in nearshore marine areas where hawksbills occur.

Populations in the Action Area.

Broad Ocean Area: 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. 2008). Hawksbills are known to nest on Maui, Molokai, and more abundantly on the Big Island of Hawai`i (NOAA 2018a). In the central Pacific, hawksbills are also known to nest on beaches in American Samoa, Fiji, the Mariana Archipelago, Micronesia, Palau, the Solomon Islands, and Vanuatu (NMFS and USFWS 2013b). Very little is known about open ocean distribution of hawksbills in the BOA. Hawksbills tend to make short-range movements between nearshore nesting and feeding areas, rather than the long-range open-ocean migrations typical of other sea turtle species (NMFS and USFWS 2007c; Parker et al. 2009). Overall, Hawksbills in the central Pacific have shown decreasing population trends both in the historic and recent time frames (NMFS and USFWS 2013b).

Vicinity of Illeginni Islet: Hawksbill turtles occur in deep ocean waters of the RMI as hatchlings, pelagic juveniles, and migrating adults, but little is known of their distribution in these waters (see above information for the BOA). As described above, hawksbill turtles forage in nearshore habitats. Depths in this region of the RMI generally range between 2,000 and 5,000 m (6,560 and 16,400 ft; Hein et al. 1999). Shallow lagoons throughout RMI provide significant areas of potential foraging habitat for green and possibly hawksbill turtles (Eckert 1993). Historical sightings of this species have occurred in these nearshore areas.

Hawksbill nesting activity was reported on Wotje Islet in 1991 and at Nibung Islet in 1989 (NMFS and USFWS 1998a). In May 2009, a hawksbill nested on the lagoon side of Omelek Islet near the harbor area (Malone 2009). The eggs hatched in early July and were inventoried. Thirteen unhatched eggs and 101 hatched eggs were counted. Two partially hatched turtles were found, and five hatchlings were assisted out of the nest into the ocean. In a 2008 survey of USAKA, suitable nesting habitat (relatively open sandy beaches and seaward margins of herbaceous strand above tidal influence) for sea turtles was identified on Illeginni Islet (Figure 4-2), and these areas were thoroughly surveyed on foot for nesting pits and tracks. These nesting and haulout habitats were reevaluated during the 2010 inventory and were determined to still be suitable habitat; however, no sea turtle nests or nesting activity have been observed on Illeginni in over 20 years (since 1996).

Known hawksbill sea turtle activity in the vicinity of Illeginni Islet is limited to the following individual sightings:

- A hawksbill was observed near shore in the lagoon north of Illeginni in 2002 (USFWS and NMFS 2004);
- An adult hawksbill was observed during a 2004 marine survey of an area extending over the lagoon-facing reef northwest of the harbor to a point across from the northwestern corner of the islet. The survey occurred at depths from 5 to 10 m (16 to 33 ft; USFWS and NMFS 2006). This high-relief habitat supports a complex community of coral, a foraging area for hawksbills;
- In 2006, a sea turtle (unknown species) was documented near Illeginni Islet;
- An adult hawksbill was observed in the outer lagoon reef flat at Illeginni Islet; and
- Sea turtle nest pits (unidentified species) were last found on Illeginni Islet in 1996, on the northern tip of the islet. No nesting was observed in surveys taken in 1998, 2000, 2002, 2004, 2006, or 2008, although suitable sea turtle nesting habitat was observed (USFWS 2011a).

Suitable nesting habitat appears northwest and east of the helipad on the lagoon side of Illeginni (Figure 4-2; USFWS and NMFS 2002).

The reported observations listed above were made during single-day surveys that were part of biennial resource inventories. These surveys were very limited in scope and effort, lasting for only a few hours and usually done by three people. The low number of sightings near Illeginni Islet may be attributed to the low level of effort expended to observe sea turtles there.

4.3.5 Olive Ridley Turtle (*Lepidochelys olivacea*)

Species Description. The general population of olive ridley turtles is listed as threatened under the ESA. The east Pacific Ocean coast nesting population segment has been listed as endangered due to the overharvest and subsequent population decline of olive ridleys in Mexico (NMFS and USFWS 2007a). There is some evidence that the olive ridley turtles found near the Hawaiian Islands are a part of the east Pacific Ocean population which breeds on beaches of central America (NMFS and USFWS 2014). In 2007, it appeared that this population was stable or increasing (NMFS and USFWS 2007a); however recent data suggest that there still may be a decreasing trend in this population (NMFS and USFWS 2014). Olive ridleys are mostly carnivorous. They consume a variety of prey including snails, clams, tunicates, fish, fish eggs, crabs, oysters, sea urchins, shrimp, and jellyfish (Mortimer 1995; Polovina et al. 2004). Oceanic turtles with depth recorders were found to spend 40% of their time at the surface and about 90% of their time at depths less than 40 m (131 ft) but dive deeper than 150 m (492 ft) regularly (Polovina et al. 2004).

Distribution. The olive ridley turtle is found in tropical waters of the south Atlantic, Pacific, and Indian oceans, generally between 30° N and 30° S. While these turtles occupy the neritic zone during the breeding season, turtles spend most of the non-breeding portions of their lives in the open ocean (NMFS and USFWS 2014). Olive ridley turtles in the eastern Pacific have migration patterns unlike other sea turtles or other populations of olive ridley turtles (NMFS and USFWS 2014). Their migratory patterns vary annually, and these turtles appear to be nomadic migrants that swim hundreds to thousands of kilometers over vast oceanic areas (NMFS and USFWS 2014). Olive ridleys are considered nomadic in the eastern Pacific and appear to forage throughout the area, often in large groups where they are associated with highly productive areas (NMFS and USFWS 2014). In the eastern Pacific, most olive ridley group nesting beaches are found on the Pacific coast of Mexico with some solitary nesting along the entire Pacific coast of Mexico (NMFS and USFWS 2014). Little is known about the occurrence of olive ridley turtles in the Action Area.

Threats. Olive ridley turtles are susceptible to the same potential threats that are generally applicable to all turtle species known to occur in the Action Area. There are no known threats in the Action Area that are specific to olive ridley turtles.

Populations in the Action Area.
Broad Ocean Area: An estimated 31 olive ridley turtles reportedly had been stranded in the Hawaiian Islands between 1982 and 2003, but there have been few recorded sightings in the nearshore waters of the main Hawaiian Islands and Nihoa (Chaloupka et al. 2008). Available information suggests that olive ridleys traverse through the oceanic waters surrounding the Hawaiian Islands during foraging and developmental migrations (Polovina et al. 2004). Although no estimates are available, the highest densities of olive ridleys are likely found just south of Hawai`i, as their distribution in the central Pacific Ocean is primarily tropical (Polovina et al. 2004). Olive ridley turtles caught in the Hawai`i longline fishery and affixed with transmitters (n=10) were recorded between 8 and 31° N in the subtropical gyre

and equatorial currents (Polovina et al. 2004). About 18% of the sea turtles incidentally caught by the Hawai`i-based longline fishery, which operates throughout this region, are olive ridley turtles (NMFS and USFWS 1998c). Olive ridleys that nest in Mexico and Central America migrate through the North Pacific Ocean (NMFS and USFWS 2007a).

Vicinity of Illeginni Islet: This species is not known to occur in the vicinity of Illeginni Islet.

4.4 Fish

The marine environment surrounding Illeginni Islet provides a diversity of fish habitat including many reef habitats typical of atolls in the central Pacific, protected lagoon habitats, and deeper ocean habitats surrounding Kwajalein Atoll. There are seven species of fish that require consultation that have the potential to occur in the Action Area (Table 4-1 and Table 4-5). Three species are listed as threatened under the ESA: the oceanic whitetip shark, the oceanic giant manta ray, and the scalloped hammerhead shark. Four other fish species are protected under the UES: the bigeye thresher shark, humphead wrasse, reef manta ray, and Pacific bluefin tuna. The bigeye thresher shark, oceanic whitetip shark, oceanic giant manta ray, and Pacific bluefin tuna are primarily open ocean species and have the potential to occur in the BOA and in deep ocean waters near Kwajalein Atoll. Relatively little is known about scalloped hammerhead sharks, but this species does have an affinity for coastal environments where it is known to give birth to live young. Juveniles are known to occur in relatively shallow nearshore waters, and adults are known to occur in deeper coastal waters. It is not expected to be present in the BOA, but it may be found in Kwajalein Atoll or nearby deep ocean waters. The reef manta ray is a shallow water species found primarily in or near reef habitats and may be present in the vicinity of Illeginni Islet. The humphead wrasse is reef-associated and found in reef habitat throughout Kwajalein Atoll including waters surrounding Illeginni Islet. It is a broadcast spawner that releases massive amounts of eggs and sperm, which become planktonic larvae before settling on the reef. Humphead wrasse larvae are not known to occur in the BOA, which is very far from larval sources. Larvae may be intermittently present in the deep ocean waters near Kwajalein Atoll, but it is expected that fish larvae there would be very sparsely represented. Larvae in the vicinity of Illeginni Islet may be more abundant, but still intermittent and patchy in distribution.

Table 4-5
Fish Presence in the Broad Ocean Area (BOA) and Near Illeginni Islet, Kwajalein Atoll.

Common Name	Scientific Name	ESA Listing Status	Protection Status	Likelihood of Occurrence: in the BOA	Likelihood of Occurrence: Near Illeginni Islet
Bigeye thresher shark	*Alopias superciliosus*	-	UES	L	U
Oceanic whitetip shark	*Carcharhinus longimanus*	T	UES	L	U
Humphead wrasse	*Cheilinus undulatus*	-	UES	U	L
Reef manta ray	*Manta alfredi*	-	UES	U	P
Oceanic giant manta ray	*M. birostris*	T	UES	P	P
Scalloped hammerhead shark	*Sphyrna lewini*	T	UES	U	P
Pacific bluefin tuna	*Thunnus orientalis*	-	UES	P	U

Sources: NOAA 2018a, IUCN 2018, USASMDC/ARSTRAT 2018
T: Threatened, UES: UES protection (USASMDC/ARSTRAT 2018)
L: Likely, P: Potential, U: Unlikely or does not occur in this portion of the Action Area

There is no designated critical habitat in the Action Area for fish.

Summary of Threats to Fish. Due to their differing life histories, these fish species have many species-specific threats as discussed below. The reef-associated humphead wrasse is known to have close associations with coral cover (Sadovy et al. 2003) and is threatened by habitat loss and degradation, specifically destruction and degradation of reef habitats (NMFS 2009). The shark species are primarily threatened by overutilization due to targeted fishing as well as capture as bycatch in commercial fisheries.

Fish Hearing. While little is known about the specific hearing capabilities of fish in the Action Area, most fish are able to detect a wide range of sounds from below 50 Hz up to 500 to 1,500 Hz (Popper and Hastings 2009). Potential responses to sound disturbance in fish include temporary behavioral changes, stress, hearing loss (temporary or permanent), tissue damage (such as damage to the swim bladder), or mortality (Popper and Hastings 2009). In studies of other fish, short duration sounds with peaks less than 176 dB re 1 μPa were found to temporarily alter fish behavior, cause temporary threshold shifts (temporary hearing alteration), but caused no observable physical damage (Popper and Hastings 2009). It is important to note that the effects of sound on these fishes are largely unknown as are sound effects on the eggs and larvae of these fish. Some researchers suggest threshold guidelines of a peak exposure of 206 dB for physical injury of fish, a 189 dB sound exposure level (SEL) for auditory tissue damage, and 150 dB for behavioral effects (Oestman et al. 2009).

4.4.1 Bigeye Thresher Shark (*Alopias superciliosus*)

Species Description. In April 2015, NMFS was petitioned to list the bigeye thresher shark as threatened or endangered under the ESA and to designate critical habitat for the species (Defenders of Wildlife 2015a). In August 2015, in its 90-day finding, NMFS determined that this action may be warranted and initiated a status review to determine whether the species will be officially listed (NMFS 2015d). The NMFS cited decreasing trends in global bigeye thresher populations and continued overutilization in its 90-day finding as a reason for potential listing. In April 2016, NMFS issued their 12-month finding on the petition and concluded that the bigeye thresher shark does not warrant listing at this time (81 FR 18979 [April 1, 2016]). Though this species is not listed under the ESA it is currently protected under the UES (USASMDC/ARSTRAT 2018 Section 3-4.5.1). This large, broad-headed shark has an elongated upper caudal lobe and distinctive large eyes (NMFS 2015d). Bigeye threshers feed on small to medium sized pelagic fishes, bottom fishes, and cephalopods and use their whip-like tail to stun and disorient prey (NMFS 2015d).

Bigeye thresher sharks are ovoviviparous and give birth to 2 to 4 pups after a 12-month gestation (NMFS 2015d). Bigeye thresher sharks reproduce year-round but have low fecundity (Fu et al. 2016). Much of their reproductive phenology remains unknown (NMFS 2015d).

Distribution. The bigeye thresher shark is found throughout the world in tropical and temperate seas (NMFS 2015c). These sharks occur throughout the Pacific Ocean. In the eastern central Pacific, bigeye thresher sharks are known to occur from the area between Wake, Marshall, Howland and Baker, Palmyra, Johnston, and the Hawaiian Islands. Neonates and juvenile thresher sharks in the Pacific were found to be clustered near 10° N and S latitudes with pregnant females either at 10° N or at higher latitudes (20–30° N; Fu et al. 2016). Habitat of the bigeye thresher is fairly broad including coastal waters over continental shelves, the epipelagic zone on the high seas, deep waters on continental slopes, and sometimes shallow inshore waters (NMFS 2015d). The bigeye thresher is thought to be a highly migratory species (Defenders of Wildlife 2015a); however, little is known about migrations, especially in the Pacific Ocean. Tagging studies of bigeye thresher sharks off Hawai`i reported movements with maximum linear displacement of nearly 3,500 km (2,175 mi) over 240 days (Fu et al. 2016) These sharks are also move vertically in the water column throughout a day, feeding in deeper waters (up to 500 m [1,640 ft]) during the day and staying near the surface at night (Fu et al. 2016). Tagged sharks in the central Pacific were significantly more active at night than during the day with mean depths of 331 m (1,086 ft) during the day and 118 m (387 ft) at night (Musyl et al. 2011).

Threats. Little is known about global abundance of the bigeye thresher. In the eastern central Pacific, populations of these sharks may have declined 83% since surveys were conducted in the 1950s (Defenders of Wildlife 2015a). Reasons for the continued declines in this species are primarily overutilization and the inadequacy of existing regulatory mechanisms (Defenders of Wildlife 2015a). Overutilization from fishing is one of the primary threats to bigeye thresher populations. Commercial fishing, incidental bycatch in commercial fisheries, and recreational fishing have led to historical declines and due to the inadequacy of existing regulatory mechanisms, those fishing pressures remain a problem for shark populations (Defenders of Wildlife 2015a). Other factors cited as contributing to population declines are susceptibility due to low reproductive rates, late sexual maturation, and large migration distances.

Populations in the Action Area.
Broad Ocean Area: Little is known about the distribution and abundance of the bigeye thresher shark in the central Pacific. The bigeye thresher is known to occur in deep ocean waters near the Hawaiian Islands (Defenders of Wildlife 2015a) and has also been observed in deep ocean waters of the Marshall Islands (Gilman et al. 2014). The highest densities of bigeye thresher sharks in the Pacific is between 5 and 15° N (Figure 4-3; Fu et al. 2016). Models of thresher shark density have used an upper bound of two million sharks for the population in the Pacific, which corresponds to a less than 5% chance of encountering more than one shark per km^2 in the areas of highest density (Figure 4-3; Fu et al. 2016). Based on this shark's propensity for long distance migration and for feeding in deep waters, as well as on models of density in the Pacific, it is likely to occur in the BOA portion of the Action Area.

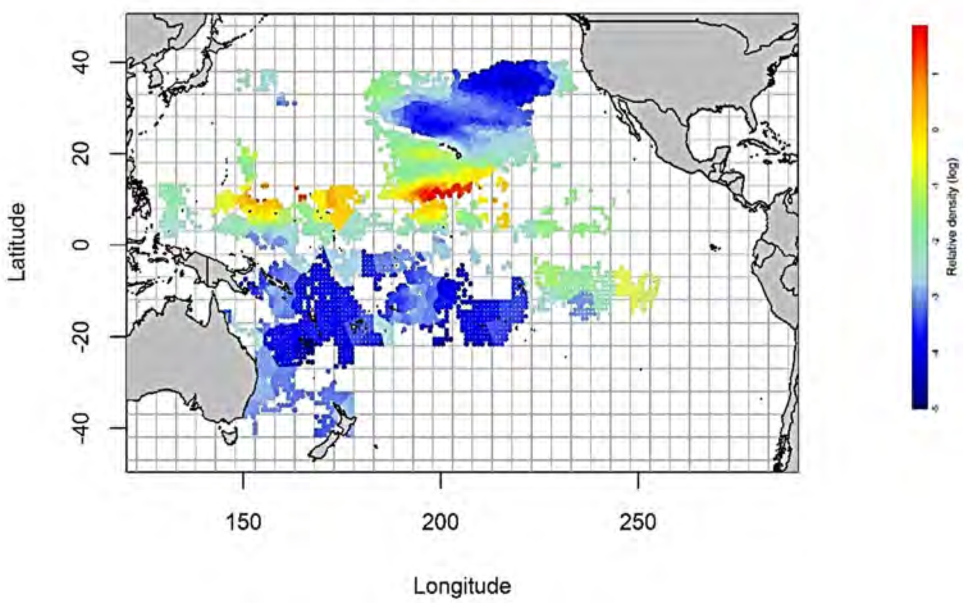

Figure 4-3. Relative Density Estimates for Bigeye Thresher Sharks in the Pacific Based on Predictive Models. Approximately 50% of the estimated population (2 million sharks) was located in the areas of high relative density (red). Figure from Fu et al. 2016.

Vicinity of Illeginni Islet: The bigeye thresher shark is known to occur in the vicinity of the Marshall Islands. Onboard observers of the Marshall Islands longline tuna fishery between 2005 and 2009 documented capture of several shark species including the bigeye thresher shark (Gilman et al. 2014). However, this species in not known to occur in the vicinity of Illeginni Islet.

4.4.2 Oceanic Whitetip Shark (*Carcharhinus longimanus*)

Species Description. In September 2015, NMFS was petitioned to list the oceanic whitetip shark as threatened or endangered under the ESA and to designate critical habitat for the species (Defenders of Wildlife 2015c). In January 2018, NMFS issued a final rule to list the oceanic whitetip shark as a threatened species under the ESA (83 FR 4153 [January 30, 2018]). This large, highly migratory shark usually swims at or near the water surface with their huge pectoral fins outspread (Young et al. 2018). Oceanic whitetip sharks feed mainly on teleost fishes and cephalopods but have been known to feed on sea birds, marine mammals, other sharks, mollusks, and crustaceans (Young et al. 2018). This viviparous shark typically gives birth to 1 to 14 pups every other year after a 10 to 12-month gestation period (Young et al. 2018). In the US waters of the Pacific, Essential Fish Habitat for the oceanic whitetip shark is defined as the water column down to a depth of 1,000 m (621 ft) from the shoreline to the outer limit of the EEZ (Young et al. 2018).

Distribution. The oceanic whitetip is a highly migratory species and is one of the most widespread shark species in tropical and subtropical waters of the world (Young et al. 2018). This species is found in waters between 30º N and 35º S latitude; however, prefers open ocean waters between 10° N and 10° S (Young et al. 2018). The oceanic whitetip is found throughout the western and central Pacific Ocean including the Hawaiian Islands south to Samoa, Tahiti, and Tuamotu Archipelago and west to the Galapagos (Young et al. 2018). While these sharks may occasionally be found in coastal waters, these sharks are usually found far offshore in the open ocean, on the outer continental shelf, or around oceanic islands in deeper waters (Young et al. 2018). Abundance of this species has been observed to increase away from continental and insular shelves and is generally found in waters with bottom depths greater than 184 m (604 ft; Young et al. 2018). Tagged sharks in the central Pacific spent most of their time in around 30 m (98 ft) deep both night and day with maximum depth of 317 m (1,040 ft; Musyl et al 2011). While oceanic whitetips are highly migratory, traveling hundreds to thousands of kilometers, there is evidence that these sharks commonly return to the same general areas over time (Defenders of Wildlife 2015c).

Threats. Western and central Pacific Ocean populations of the oceanic whitetip shark have been estimated to have declined by as much as 90% from 1996 to 2009 (Defenders of Wildlife 2015c). Major threats to this species include modification or reduction of habitat, overutilization, disease, and the inadequacy of existing regulatory mechanisms (Defenders of Wildlife 2015c). Overutilization includes historical and continued catch in targeted commercial fisheries for their fins, skin, and liver oil and as bycatch in tuna and swordfish fisheries (Defenders of Wildlife 2015c). This species is also considered vulnerable to decline due to their infrequent and low output reproduction strategy (Defenders of Wildlife 2015c).

Populations in the Action Area.
Broad Ocean Area: This species is known to occur in deeper oceanic waters near the Hawaiian Islands and near the RMI (Defenders of Wildlife 2015c, Rice et al. 2015). While little is known about the distribution and abundance of these sharks in the BOA, some tagged sharks have been tracked through

the broad ocean areas of the central Pacific, and these fish are regularly recorded by observers on longline fishing vessels (Rice and Harley 2012, Defenders of Wildlife 2015c, Rice et al. 2015).

Vicinity of Illeginni Islet: The oceanic whitetip shark is one of the most common shark species caught in the RMI (Young et al. 2018). From 2005-2009, observers in the RMI longline fisheries reported a catch per unit effort of 0.2904 fish per 1,000 hooks for oceanic whitetip sharks (Young et al. 2018). Even though the oceanic whitetip shark is known to occur in deep ocean waters of the RMI (Rice et al. 2015, Young et al. 2018), this shark is not known to occur in the shallow waters in the vicinity of Illeginni Islet.

4.4.3 Humphead Wrasse (*Cheilinus undulatus*)

Species Description. In October 2012, NMFS was petitioned to list the humphead wrasse as threatened or endangered under the ESA and to designate critical habitat for the species. In February 2013, in its 90-day finding, NMFS determined that this action may be warranted and initiated a status review to determine whether the species would be officially listed (78 FR 13614 [February 28, 2013]). In September 2014, NMFS determined that ESA listing of the humphead wrasse was not warranted (79 FR 57875 [September 26, 2014]). However, this species remains protected under the UES and is therefore a consultation species.

The humphead wrasse is found at low densities (one to eight per acre) where it occurs, even in its preferred habitat (Donaldson and Sadovy 2001). Humphead wrasses are observed as solitary male/female pairs or in small groups of two to seven individuals (NMFS 2009). The humphead wrasse is a predator of echinoderms including brittle stars, sea stars, and sea urchins, as well as of mollusks and crustaceans (WildEarth Guardians 2012). The feeding ecology of this wrasse may be beneficial to coral reefs, as their diet includes the crown of thorns starfish, which feeds on coral (WildEarth Guardians 2012).

Distribution. The humphead wrasse occurs in coral reef regions of the Indo-Pacific in waters from 1 to 100 m (3 to 330 ft) deep (WildEarth Guardians 2012). Both juveniles and adults utilize reef habitats. Juveniles inhabit denser coral reefs closer to shore and adults live in deeper, more open water at the edges of reefs in channels, channel slopes, and lagoon reef slopes (Donaldson and Sadovy 2001). While there is limited knowledge of their movements, it is believed that adults are largely sedentary over a patch of reef and during certain times of the year they move short distances to congregate at spawning sites (NMFS 2009). Humphead wrasse density increases with hard coral cover, where smaller fish are found in areas with greater hard coral cover (Sadovy et al. 2003).

Threats. The uncommon populations of this species have been in decline due to threats from overharvest as well as habitat destruction and degradation (NMFS 2009). The humphead wrasse is especially vulnerable to overharvest by both legal and illegal fishing activities due to their long lifespan, large size, and unique life history of female to male sex change later in life (NMFS 2009). Another significant threat to the decline of the species is habitat loss and degradation, specifically destruction and degradation of reef habitats, which is common throughout the Indo-Pacific (NMFS 2009).

Populations in the Action Area.
Broad Ocean Area: This species is not known to occur in the BOA of the Action Area.

Vicinity of Illeginni Islet: The humphead wrasse is known to occur in the vicinity of Illeginni Islet (Table 4-6). As was found in other studies (Donaldson and Sadovy 2001), the humphead wrasse appears to occur in low densities throughout the Kwajalein Atoll area in NMFS and USFWS biennial surveys. Occurrence records of *C. undulatus* suggest a broad, but scattered distribution at USAKA with observations of the species at 26% (32 of 125) of sites at 10 of the 11 surveyed islets since 2010 (Table 4-6). Adult humphead wrasses have been recorded in seaward reef habitats at Illeginni Islet (shallowest depths approximately 5 m (15 ft) deep (USFWS and NMFS 2012, NMFS and USFWS 2018). Although encountered on numerous occasions at USAKA, direct density measures of *C. undulatus* have not been obtained. The adults of this species may range very widely, with typically four or fewer individuals observed within a broad spatial reef area (Dr. Robert Schroeder, NMFS). Two neighboring seaward reef flat sites in 2008 were noted to have adult *C. undulatus* present (USFWS 2011a); thus, a total of eight adult individuals might be exposed to potential MMIII impacts in this region. Absent a direct physical or sound related impact, the adults might be expected to show temporary curiosity, altered feeding patterns, and/or displacement.

Shallow inshore branching coral areas with bushy macro-algae, such as those which may exist along the shallow lagoon reef flat at Illeginni Islet, have been noted as potential essential nursery habitat for juvenile *C. undulatus* (Tupper 2007). Recent settler and juvenile numbers are presumed to greatly exceed 20 in such habitat (Tupper 2007) and might be grossly approximated to range from 0 to 100 within the lagoon-side waters of Illeginni (NMFS 2014). A direct physical strike from a payload fragment, toppling or scattering of coral habitat and/or reef substrate, increased exposure to predation through displacement, and/or sound impacts may result in mortalities of juvenile *C. undulatus*, assuming they are present within the impact area. Otherwise, loss of habitat may lead to simple displacement, but with a longer-term functional loss of nursery potential contingent both spatially and temporarily on habitat recovery potential (NMFS 2014).

Table 4-6
Number of Survey Sites (2010 to present) with Observed UES Fish Consultation Species and Occurrences at USAKA (KI = Kwajalein, RN = Roi Namur, MK = Meck, OM = Omelek, EN = Ennylabegan, LG = Legan, IL = Illeginni, GA = Gagan, GN = Gellinam, EK = Eniwetak, ET = Ennugarett, and MAC = Mid-Atoll Corridor). [1]

Family Scientific Name	RN	ET	GA	GL	OM	EK	MK	IL	LG	EN	KI	MAC	Total	# of Islets
Labridae														
Cheilinus undulatus	4	3	3	1	3	1	1	**1**	-	3	9	3	**32**	10
Mobulidae														
Manta sp.[2]	-	-	-	-	-	1	-	**1**	-	-	2	-	**4**	3
No. Sites Surveyed	**13**	**8**	**5**	**8**	**7**	**5**	**8**	**5**	**7**	**5**	**19**	**35**	**125**	**11**

[1] Sources: USFWS and NMFS 2012, NMFS and USFWS 2013a, NMFS and USFWS 2017, NMFS and USFWS 2018.

[2] The 2010 and 2016 inventory reports list *Manta birostris* for these observations. While not recorded during biennial inventories of USAKA islets, *Manta alfredi* is also known to occur in Kwajalein Atoll waters.

Cheilinus undulatus have been observed to aggregate at discrete seaward edges of deep slope drop-offs to broadcast spawn in the water column; they do not deposit their eggs on the substrate (Colin 2010). This type of behavior is not known at Illeginni Islet, but it may exist; however, similar habitat would occur in nearby waters. The flow dynamics of developing fish eggs and larvae around Illeginni Islet are not understood. Initial flow may be away from the islet, with future return or larval/adult source dynamics from another area. No information exists to support any reasonable estimation of potential FE-

2 impacts to *C. undulatus* eggs and developing larvae (NMFS 2014). At present, the likelihood for such impact appears discountable.

4.4.4 Reef Manta Ray (*Manta alfredi*)

Species Description. In November 2015, NMFS was petitioned to list the reef manta ray as threatened or endangered under the ESA (Defenders of Wildlife 2015b). In January 2017, NMFS announced a 12-month finding on the petition to list the reef manta ray and found that this species did not warrant listing under the ESA (82 FR 3694-3715 [January 12, 2017]). Though this species is not listed under the ESA it is currently protected under the UES (USASMDC/ARSTRAT 2018 Section 3-4.5.1). Until 2009, all manta rays were considered a single species, *Manta birostris*. There are currently two species of manta ray, *M. alfredi* and *M. birostris*, as supported by morphological and genetic data (Marshall et al. 2011a). The giant manta ray is a more oceanic species while the reef manta ray is primarily a nearshore species. Consequently, many historic records of manta rays in nearshore waters likely refer to what is now known as the reef manta ray. While somewhat smaller than the giant manta ray, the reef manta ray is a large, cartilaginous elasmobranch up to 5 m (16.4 ft) long (Marshall et al. 2011a). This species feeds on plankton, which it filters from seawater using gill plates (Defenders of Wildlife 2015b). While long lived, this species exhibits very low fecundity, typically producing only a single pup biennially after a 1-year gestation period (Marshall et al. 2011a). Females are thought to mature at 8 to 10 years, while males are known to breed as early as 6 years of age (Marshall et al. 2011a).

Distribution. This species has a circumglobal distribution in tropical and sub-tropical waters but is often resident in or along productive near-shore environments (Marshall et al. 2011a). The reef manta ray is typically found inshore but has also been observed offshore around coral reefs, rocky reefs, and seamounts (Marshall et al. 2011a). Acoustic tracking data suggest that reef manta rays do not often leave coastal waters, remaining within 6 km (3 nm) of shore (Clark 2010). It is thought that this species is less migratory than the giant manta ray with smaller home ranges and established aggregation sites (Marshall et al. 2011a). While they exhibit shorter migrations than the giant manta ray, the reef manta is known to migrate up to 500 km (270 nm) and up to 190 km (103 nm) from shore and diving up to 300 m (984 ft; Marshall et al. 2011a). In Hawai`i, reef mantas may have even more limited movement, with no documented movement of rays between islands only 48 km (26 nm) apart (Clark 2010).

Threats. Globally, reef manta rays have decreasing population numbers (Marshall et al. 2011a). Major threats to this species include both targeted and bycatch fishing (Marshall et al. 2011a). Manta rays are fished for meat, for their epidermis which is used for leather products, and for their gill rakers which are highly prized for use in Chinese medicinal products (Marshall et al. 2011a). Manta rays are also caught as bycatch in gillnet, purse seine, and other netting operations as well as entangled in monofilament fishing line (Marshall et al. 2011a).

Populations in the Action Area.
Broad Ocean Area: This nearshore species is not known to occur in the BOA of the Action Area.

Vicinity of Illeginni Islet: Manta rays were observed during 2010 and 2016 inventories of Kwajalein Atoll islets (Table 4-6). While these observations at two locations near Kwajalein Islet in 2010 and at single locations near Eniwetak, Illeginni, and Kwajalein Islets in 2016 were recorded as observations of *Manta birostris* (giant manta ray), *Manta alfredi* is also known to occur in Kwajalein Atoll (V. Brown personal communication 2018). No abundance data is available for reef manta rays in Kwajalein Atoll; however, density data is available for another Pacific island with similar reef ecosystems, Guam. Data from a long-term study of the insular coral reef ecosystem of Guam resulted in an overall density estimate of less than 0.01 individuals per km^2 (Martin et al. 2016). Densities in this study ranged from 0.0 to 0.03 per km^2 with the highest densities in reef habitats predominantly covered by coral, turf, and macroalgae and in Marine Protected Areas around Guam (Martin et al. 2016). While this species is known to occur in nearshore waters of Kwajalein Atoll, there are no known records of the species in the vicinity of Illeginni Islet.

4.4.5 Oceanic Giant Manta Ray (*Manta birostris*)

Species Description. In November 2015, NMFS was petitioned to list the giant manta ray as threatened or endangered under the ESA (Defenders of Wildlife 2015b). In January 2018, NMFS announced a final rule to list the giant manta ray as threatened under the ESA (83 FR 2916 [January 22, 2018]). Until 2009, all manta rays were considered a single species, *Manta birostris*. There are currently two species of manta ray, *M. alfredi* and *M. birostris*, as supported by morphological and genetic data (Marshall et al. 2011b). The giant manta ray is a more oceanic species while the reef manta ray is primarily a nearshore species. Consequently, many historic records of manta rays in nearshore waters likely refer to what is now known as the reef manta ray. The giant manta ray reaches lengths of 7 m (23 ft) long and feeds on plankton, which it filters from seawater using gill plates (Defenders of Wildlife 2015b). While little is known about the life history of this species it is thought to be long lived and likely has low fecundity, with reports of litter size consistently being of a single offspring (Marshall et al. 2011b).

Distribution. This species has a circumglobal distribution in tropical and temperate waters. The giant manta ray is commonly sighted along productive coastlines with upwelling and primarily occurs near offshore pinnacles and seamounts (Marshall et al. 2011b). This species is thought to spend the majority of its time in deep water with occasional visits to coastal areas (Defenders of Wildlife 2015b). This species is commonly observed during cleaning visits to shallow reefs or feeding at the surface inshore and offshore. While more solitary than the reef manta ray, the giant manta ray is a seasonal migrant to coastal and offshore aggregation sites (Marshall et al. 2011b). An investigation of these aggregation sites indicated that the giant manta ray may be a more oceanic and more migratory species than the reef manta ray and may migrate over 1,100 km (594 nm; Marshall et al. 2011b). These long-distance movements may be rare, however. Based on satellite tagging, stable isotope, and genetic analysis, Stewart et al. (2016) found that Indo-Pacific oceanic manta rays form well-structured subpopulations with a high degree of residency. This species has been tracked diving to depths exceeding 1,000 m (3,281 ft; Marshall et al. 2011b). In locations were the giant manta ray is sympatric with the reef manta ray, the species typically exhibit different habitat use and movement patterns (Marshall et al. 2011b).

Threats. Globally, giant manta rays have decreasing population numbers (Marshall et al. 2011b). In its status review report, NMFS indicated the most significant threat to the giant manta ray was overutilization for commercial purposes (Miller and Klimovich 2016). This species is subject to both targeted and bycatch fishing (Marshall et al. 2011b, Miller and Klimovich 2016). Manta rays are fished for meat, for their epidermis which is used for leather products, and for their gill rakers which are highly prized for use in Chinese medicinal products (Marshall et al. 2011b). Manta rays are also caught as bycatch in gillnet, purse seine, and other netting operations as well as entangled in monofilament fishing line (Marshall et al. 2011a). This species is especially vulnerable to threats that decrease its abundance due to their low reproductive output (Miller and Klimovich 2016).

Populations in the Action Area.
Broad Ocean Area: This species may occur in portions of the BOA, especially in areas near offshore pinnacles and seamounts. Populations of this species and migratory habits in the BOA are poorly known. While individuals may aggregate at cleaning or feeding sites, this species is rarely encountered

in large numbers and is observed with far less frequency that the reef manta ray (Marshall et al. 2011b). Regional populations are thought to be small, but the species is known to occur near the Hawaiian Islands and the Northern Mariana Islands (Clark 2010, Defenders of Wildlife 2015b).

Vicinity of Illeginni Islet: Manta rays were observed during 2010 and 2016 inventories of Kwajalein Atoll islets (Table 4-6). *Manta* observations at two locations near Kwajalein Islet in 2010 and at single locations near Eniwetak, Illeginni, and Kwajalein Islets in 2016 were recorded as observations of *Manta birostris.* While the giant manta ray is generally a more oceanic species than the reef manta ray, both species are known to occur in Kwajalein Atoll waters (V. Brown personal communication 2018). No abundance data is available for oceanic manta rays in Kwajalein Atoll or other areas of the Central Pacific.

4.4.6 Scalloped Hammerhead Shark (*Sphyrna lewini*)

Species Description. In August 2011, NMFS was petitioned to list the scalloped hammerhead shark as threatened or endangered under the ESA and to designate critical habitat with the listing. In its 90-day review, NMFS concluded that substantial scientific information might warrant listing under the ESA. In March 2013, after a comprehensive status review, six DPSs of the scalloped hammerhead shark were recognized (78 FR 20717 [April 5, 2013]), two of which occur in the Action Area. The Indo-West Pacific DPS was proposed for listing as a threatened species (78 FR 20717 [April 5, 2013] with high risk due to overutilization by industrial, commercial, and artisanal fisheries as well as illegal and unregulated fishing (Miller et al. 2013). The central Pacific DPS, which includes waters surrounding the Hawaiian Islands, was deemed not warranted for listing under the ESA (78 FR 20718 [April 5, 2013]).

Scalloped hammerhead sharks occur as solitary individuals, or in aggregations or schools associated with feeding habitats (e.g., near islands, reefs, or seamounts) or during the spawning season (Klimley 1981; Compagno 1984). This species is ovoviviparous, giving birth to multiple live young in warm nearshore waters. Throughout the species' range, females migrate to coastal areas to give birth; in the Eastern Tropical Pacific, this occurs between May and July (Baum et al. 2007). Neonates and pups are known to occur in high concentrations in estuaries and bays for up to two years before moving offshore to shelf habitats (Baum et al. 2007). In the Hawaiian Islands, protected bays are utilized as juvenile nursery habitats between May and September. Pups move throughout the bay during a residency of approximately one year, with no discernible pattern in habitat use (Duncan and Holland 2006). Around the Galapagos Islands, scalloped hammerheads show a preference for nearshore and trench environments, which are thought to be foraging habitats (Ketchum 2011). At Galapagos, hammerheads remain in shallower waters during the warm season and in deeper waters in the cold season. The sharks move near or above the thermocline, presumably to thermoregulate (Ketchum 2011).

The scalloped hammerhead shark is a high-level trophic predator and feeds primarily at night (Compagno 1984; Bush and Holland 2002; Hussey et al. 2011). They feed opportunistically on teleost fishes, cephalopods, crustaceans, and rays (Compagno 1984; Vaske et al. 2009; Bethea et al. 2011). Scalloped hammerhead sharks are hearing generalists and, like many fishes, possess a lateral line sensory system sensitive to particle motion in the water column (Popper 2003). Electroreception is the primary sensory mechanism used by many sharks. Sharks have demonstrated highest sensitivity to low frequency sound (40 Hz to approximately 800 Hz), sensed solely through the particle-motion component of an acoustical field (Myrberg 2001). Free-ranging sharks are attracted to sounds possessing specific characteristics: irregularly pulsed, broadband (attractive frequencies are below 80 Hz), and transmitted without a sudden increase in intensity. Such sounds are reminiscent of those produced by struggling prey (Myrberg 2001).

Distribution. The scalloped hammerhead occurs in coastal, warm temperate waters and tropical seas throughout the world (Miller et al. 2013). This shark is found over continental and insular shelves from the surface and intertidal zones to depths of up to 512 m (1,680 ft; Miller et al. 2013). They are highly mobile and partly migratory (FAO 2006). Scalloped hammerheads typically inhabit nearshore waters of bays and estuaries where water temperatures are at least 22°C (72°F) (Compagno 1984). They remain close to shore during the day and move into deeper waters at night to feed (Bester 1999). Throughout their range, scalloped hammerhead adults occur at midwater depths over the continental shelf and near the shelf edge (Baum et al. 2007). These sharks have shown diel vertical movements in some studies. A tagged shark in the northern Gulf of Mexico showed consistent diel vertical movements, spending approximately 80% of daylight hours between depths of 50 to 100 m (164 to 328 ft) with no deep dives. Seventy percent of night hours were spent in surface waters of 0 to 50 m (0 to 164 ft), and the shark occasionally made dives to nearly 1,000 m (0.6 mi; Franks et al. 2009).

Threats. Both target and bycatch capture in fisheries is a significant cause of mortality for the species. Because scalloped hammerheads aggregate in large schools, large numbers may be captured with minimal effort. They are sought for their highly valuable fins and are being increasingly targeted in some areas.

Populations in the Action Area.
<u>*Broad Ocean Area*</u>*:* The scalloped hammerhead shark may occur in temperate to tropical waters of the BOA (Duncan and Holland 2006). Their scattered distribution in the western Pacific includes all of the tropical/temperate Pacific Islands (Baum et al. 2007). These sharks are considered to be semi-oceanic and occur primarily in coastal areas. Studies of hammerhead shark catches in longline fisheries indicate a limited distribution in the central Pacific with most catches concentrated in deeper waters off the coast of islands (Rice et al. 2015). There are no data on the abundance of scalloped hammerhead sharks in the BOA and the possibility of their presence in the deep waters of the BOA is likely to be extremely low.

<u>*Vicinity of Illeginni Islet*</u>*:* A solitary adult scalloped hammerhead shark was observed by NMFS and USFWS biologists in approximately 7.6 m (25 ft) of water seaward of the atoll reef west of Roi-Namur Islet (U.S. Navy 2017a). This species may also occur in the vicinity of Illeginni Islet, but there are no available data on occurrence for this portion of the Action Area. This species has the potential to occur in the deeper waters around Kwajalein Atoll.

4.4.7 Pacific Bluefin Tuna (*Thunnus orientalis*)

Species Description. In June 2016, NMFS was petitioned to list the Pacific bluefin tuna as threatened or endangered under the ESA (CBD 2016). In its 90-day finding, NMFS found the petition presented substantial scientific information indicating that the petition may be warranted (81 FR 70074 [October 11, 2016]). After a status review of this species (Pacific Bluefin Tuna Status Review Team 2017), NMFS determined that listing of the Pacific bluefin tuna under the ESA was not warranted (82 FR 37060 [August 8, 2017]). Even though this species is not listed under the ESA, it is currently protected under the UES as a consultation species (USASMDC/ARSTRAT 2018 Appendix 3-4A).

The Pacific bluefin tuna is one of several tuna species inhabiting the Pacific Ocean and reaches lengths of 3 m (9 ft; CBD 2016). This species is a pelagic fish that tends to form schools based on size and cohort (CBD 2016). With a streamlined shape, lunate caudal fin, retractable dorsal fins, and a rigid body to provide greater power, Pacific bluefin tuna are uniquely adapted for long distance migrations and for catching their prey, fast moving fishes (CBD 2016). While larvae and small juveniles feed on small organisms such as brine shrimp, other fish larvae, and copepods, larger juveniles and adults feed primarily on smaller fish but are known to eat a wide range of marine prey (CBD 2016). This species is a highly migratory species known to migrate over long distances from the equator to high latitudes to feed and spawn (CBD 2016). These tuna are also unusual among fish in that they can maintain their body heat up to 55°F higher than ambient water temperature (CBD 2016).

Distribution. The Pacific bluefin tuna is distributed throughout the Pacific Ocean. They primarily occur in the north Pacific between 20° N and 50° N but are also found in tropical waters and in the southern hemisphere (Pacific Bluefin Tuna Status Review Team 2017). In the eastern Pacific, populations are found in the California current from Washington State, south to Baja California (CBD 2016). In the western Pacific, fish are found from Sakhalin Island, Russia south to New Zealand and Australia (CBD 2016). There are two known spawning areas in the western Pacific (one in the East China Sea and one in the Sea of Japan), and all Pacific bluefin tuna are born in the western Pacific (CBD 2016). A majority of juveniles remain in the western Pacific; however, some migrate to the eastern Pacific in their first or second year where they feed off the Pacific coast of North America for one to four years before migrating back to the western Pacific to spawn (CBD 2016). These pelagic tunas prefer temperate waters but travel into polar and subpolar waters to feed and subtropical waters to reproduce (CBD 2016). Pacific bluefin tuna habitat includes the water column extending from the surface down to 1,000 m (3,281 ft; CBD 2016). These fish are mostly found in the upper 100 m (328 ft) of the water column but are known to make diel vertical migrations, inhabiting deeper waters during daylight hours (CBD 2016). Studies have also found that juvenile fish spent more than 50% of their time in depths shallower than 10 m (33 ft; CBD 2016).

Threats. Pacific bluefin tuna populations have decreased to approximately 2.6% of their estimated unfished biomass (CBD 2016). Major threats to this species include overutilization in both commercial and recreational fishing, overutilization in aquaculture operations, inadequacy of existing regulatory mechanisms, and destruction and modification of habitat (CBD 2016). Overfishing is the primary threat to Pacific bluefin tuna populations (CBD 2016). Because these fish are slow growing, long lived, and migrate long distances to spawn and feed, most (estimated 97.6%) are caught before they are able to spawn (CBD 2016). Destruction and modification of habitat within the species range has been primarily due to pollution from chemicals such as mercury, plastic pollution, oil and gas pollution and development, wind energy development, and prey depletion (CBD 2016).

Populations in the Action Area.
Broad Ocean Area: While the distribution of this species in the central Pacific is largely unknown, this species may occur in portions of the BOA. Pacific bluefin tuna have been caught in fisheries both north and south of the equator in the central Pacific (80 FR 70076). A NOAA (2015) summary report on the 2014 Hawai`i-based longline fisheries logbooks included only two bluefin tuna, which were caught in an EEZ outside the United States. While Pacific bluefin tuna may occur in the BOA, the main feeding areas and migratory pathways are not known to be between the Hawaiian Islands and the Kwajalein Atoll, and the abundance of this species in the BOA is likely low.

Vicinity of Illeginni Islet: While density and distribution of this species is poorly understood in this area, the Pacific bluefin tuna probably occurs in the Marshall Islands (CBD 2016, IUCN 2016). If this species does occur in the vicinity of Kwajalein Atoll, it likely has a patchy and seasonal (though unknown) distribution in deeper waters. This species is not known to occur in nearshore waters of Kwajalein Atoll, there are no known records of Pacific bluefin tuna in the vicinity of Illeginni Islet.

4.5 Corals (Phylum Cnidaria)

The marine environment surrounding Illeginni supports a community of corals that is typical of reef ecosystems in the tropical insular Pacific. Within this community are species of corals that are protected by an assortment of regulatory mechanisms (Table 4-1). There are 19 species of coral requiring consultation that have been found in the vicinity of Illeginni Islet since 2010 (Table 4-7) and an additional three consultation species that have the potential to occur in the Action Area as larvae. These species include two coral species listed as ESA-threatened, one species that is a candidate for ESA listing, and 19 corals which were found to be unwarranted for ESA listing. However, these latter 19 species are still currently protected under the UES (Table 4-1). All but one of these species are also listed as vulnerable by the International Union for Conservation of Nature (IUCN 2018). All of these species are also regulated by Appendix II of CITES (2017).

There is no designated critical habitat for ESA-candidate coral species at Illeginni Islet or elsewhere within Kwajalein Atoll.

Summary of General Coral Characteristics. All hard coral species found at Illeginni Islet are typical of shallow-water tropical Indo-Pacific coral reefs. In general, these corals may occur at depths of 0 to 30 m (0 to 100 ft), although some species have more specific depth and sub habitat preferences (Sakashita and Wolf 2009). The optimal water temperature and salinities for most shallow-water tropical corals are 77° F to 84° F (25° C to 29° C), and 34 to 37 parts per thousand, although short-term anomalies are usually tolerated, with minor physiological consequences (Wallace 1999). Corals generally require high oxygen content, low nutrient levels, and clear water to allow sufficient sunlight to support zooxanthellae (symbiotic photosynthetic organisms) (Beger et al. 2008; Spalding et al. 2001). Most coral species tolerate short-term turbidity with minimal physiological consequences, and some species tolerate long-term turbidity (Beger et al. 2008; Rogers 1990).

Predators of corals include sea stars, snails, and fishes (e.g., crown of thorns sea stars, parrotfish, and butterfly fish; Boulon et al. 2005; Gulko 1998). The crown of thorns sea stars (*Acanthaster planci*) are the primary predators of most ESA-listed and Species of Specific Biological Importance coral species known at Illeginni Islet (Table 4-1 and Table 4-7; Gulko 1998).

Corals prey on zooplankton, which are small organisms that inhabit the ocean. Corals capture prey in tentacles armed with stinging cells that surround the corals' mouths or by employing a mucus-net to catch suspended prey (Brusca and Brusca 2003). In addition to capturing prey, corals possess a unique method of acquiring essential nutrients through their relationship with zooxanthellae (a type of algae) that benefits both organisms. The coral host provides nitrogen in the form of waste to the zooxanthellae, and the zooxanthellae provide organic compounds produced by photosynthesis to its host (Brusca and Brusca 2003; Schuhmacher and Zibrowius 1985). Some corals derive most of their energy from their zooxanthellae symbionts, resulting in dramatically reduced need for the coral to feed on zooplankton (Lough and Van Oppen 2009). Zooxanthellae also provide corals with most of their characteristic color.

Coral Reproduction. Most coral species can reproduce both sexually and asexually (NOAA 2017). Most of the shallow-water species requiring consultation in Table 4-1 reproduce sexually by spawning, typically from July to December. Some species brood live young, and some coral species engage in both spawning and brooding (Fautin 2002; Gascoigne and Lipcius 2004). Most corals are capable of asexual reproduction by dividing or fragmentation (NOAA 2017). Fragmentation is most often seen in branching corals that are more likely to break (Lirman 2000). Reproductive potential (fecundity) is a function of colony age and size, and many threats to corals reduce reproductive potential by degrees, up to halting reproduction for several years (Boulon et al. 2005; Fautin 2002; Gascoigne and Lipcius 2004; Lirman 2000).

Coral are mostly hermaphroditic broadcast spawners, releasing both male and female gametes into the water in massive numbers (Harrison et al. 1984, NOAA 2017). In many regions, spawning is a mass synchronized event where many coral species release their gametes at the same time (NOAA 2017). Research into the environmental cues that lead to mass spawning has revealed many possible causes (NOAA 2017) including temperature, rate of temperature change (Keith et al. 2016), lunar phases (Harrison et al. 1984), and the time of sunset. Among corals of the Great Barrier Reef, about 130 of approximately 400 species spawn at the peak of summer (November and December) (Hughes et al. 2000). It is a reasonable assumption that this proportion would be spawning species in RMI.

After fertilization of the egg, free-floating, or planktonic, larvae form (NOAA 2017). These coral planulae are carried by water currents but are also capable of swimming vertically in the water column (NOAA 2017, Hodgson 1985). Larval duration ranges from a few days to months (reviewed by Jones et al. 2009), but short durations of 3-9 days are much more common (Hughes et al. 2000, Vermeij et al. 2010). Accordingly, dispersal ranges a few tens of meters to 2,000 km (1,080 nm), but local short-distance dispersal occurs much more frequently than long-distance dispersal (Jones et al. 2009; Mumby and Steneck 2008). Less frequent long-distance dispersal is dependent on the buoyant gametes and planktonic larvae (typically free-swimming planulae) that are more likely to be found in open ocean areas. Spatial modelling of dispersal of coral larvae across the Pacific has indicated that 50% of dispersal connectivity between reefs occurs within 50 to 100 km (27 to 54 nm; Wood et al. 2014). Altogether this information suggests that gametes and planulae will be found in the open ocean, but at very low densities. The portion of the total pool of gametes, planulae, and larvae that are likely to be found in the open ocean is likely very small.

Coral planulae density in the water directly over the reef is zero except during reproduction when density peaks at 16,000 per 100 cubic meters (m^3; 453 per 100 cubic feet [ft^3]) for some spawning species (Hodgson 1985). In a study of a reef off Oahu, Hawai`i, Hodgson (1985) sampled larvae on 4 transects from the inner reef flat to 20 m seaward of the reef and found an average abundance of all types of coral planulae of 328 per 100 m^3 (9.3 per 100 ft^3) from June to August. On the Great Barrier Reef, similar densities of coral larvae directly over the reef rapidly dispersed by three to five orders of magnitude in waters 5 km (3 mi) distant from the reef (Oliver et al. 1992). Eggs, larvae, and planulae are not homogenously distributed but sometimes travel in semi-coherent aggregations (slicks) or become concentrated along oceanic fronts (Hughes et al. 2000; Jones et al. 2009).

After their planktonic stage, coral planulae will swim down to the bottom where they will settle if conditions are favorable (NOAA 2017). Once the planulae settle, they metamorphose into polyps which are attached to the substrate (NOAA 2017). These polyps will form colonies that increase in size over time. After the colony is established (1 or 2 years), coral growth rates are generally constant as the colony ages, varying widely among species from approximately 5 to 130 millimeters (0.25 to 5 in) per year (Buddemeier et al. 1974; Edinger et al. 2000; Hoeke et al. 2011). In general, branching corals grow faster than massive or encrusting corals. Reproductive maturity is reached between three and eight years, the average generation time is 10 years, and longevity ranges from several decades to a millennium (De'ath et al. 2009; Soong et al. 1999; Wallace 1999).

Summary of Threats to Corals. The consultation coral species are all classified as vulnerable by the IUCN (2015). This means that their global population is estimated to be at least 36% reduced over three generations. In general, RMI reefs have declined in step with much of the Indo-Pacific, falling from approximately 35% cover to approximately 25% cover in the past few decades (Bruno and Selig 2007; Halpern et al. 2008). Direct estimates of population status for corals in the RMI are incomplete, although an excellent qualitative time-series data set of presence-absence has been maintained by collaboration among USAG-KA, NMFS and USFWS (USFWS and NMFS 2002, 2004, 2006, 2012; USFWS 2011a; NMFS and USFWS 2013a, 2017, 2018).

There are no known species-specific threats for any particular coral species listed in Table 4-1, although it is conceivable that some diseases are species specific. Some groups of corals are more or less susceptible to predation and general threats. For example, the predatory crown of thorns sea star (*Acanthaster planci*) feeds preferentially, but not exclusively, on *Acropora* and *Pocillopora* species (Gulko 1998). A type of "white" disease seems to preferentially affect tabular colonies of *Acropora* (Beger et al. 2008). The aquarium industry has various taxa-specific preferences and, as one of the more profitable industries in the RMI, is a potential contributor to loss of preferred populations (Pinca et al. 2002).

Factors that can stress or damage coral reefs are coastal development (Risk 2009), impacts from inland pollution and erosion (Cortes and Risk 1985), overexploitation and destructive fishing practices (Jackson et al. 2001; Pandolfi et al. 2003), global climate change and acidification (Hughes et al. 2003), disease (Beger et al. 2008; Galloway et al. 2009), predation (Richmond et al. 2002; Sakashita and Wolf 2009), harvesting by the aquarium trade (Caribbean Fishery Management Council 1994; Richmond et al. 2002), boat anchors (Burke and Maidens 2004), invasive species (Bryant et al. 1998; Galloway et al. 2009; Wilkinson 2002), ship groundings (Sakashita and Wolf 2009), oil spills (NOAA 2001), and possibly human-made noise (Vermeij et al. 2010). These threats can result in coral death from coastal runoff, reduced growth rates caused by a decrease in the pH of the ocean from pollution, reduced tolerance to global climate change, and malnutrition and weakening due to coral bleaching (Carilli et al. 2010; Cohen et al. 2009). The causes of coral bleaching are reasonably well understood and are often tied to unusually high sea temperatures (Brown 1997; Glynn 1993; van Oppen and Lough 2009). Human-made noise may affect coral larvae by masking the natural sounds that orient them toward suitable settlement sites (Vermeij et al. 2010).

All of the general threats to corals have also been identified as threats to reef ecosystems in RMI, with the exception of pH (ocean acidification) and noise (Beger et al. 2008; Hay and Sablan-Zebedy 2005). However, there is little reason to suspect that the threats posed by pH and noise would be materially different on Kwajalein Atoll than elsewhere in the Pacific. Compounding the threats in the Marshall Islands, and on Kwajalein particularly, are socioeconomic conditions that are among the worst in the Pacific (Hay and Sablan-Zebedy 2005). This indirect threat results in ineffective or deferred environmental mitigation and conservation.

Summary of Corals in the BOA. Adult shallow-water reef-associated corals (Table 4-1) that require consultation do not occur in the BOA or deep-water portions of the Action Area because their required shallow habitat is absent. At various times of the year the gametes (eggs and sperm) and larvae of reef-associated invertebrates may occur in the BOA and deep ocean waters. For corals, this is generally July to December and particularly the week following the August and September full moons. The densities of coral larvae are difficult to predict, but studies of coral larvae during peak spawning report 0.1 to 1 planktonic larvae per m^3 (per 35.31 ft^3) in waters 5 km (2.7 nm) away from the reef, and 0.3 per m^3 (0.05 per ft^3; brooding species) to 16 per m^3 (0.45 per ft^3; spawning species) in waters directly over the reef during reproduction (Hodgson 1985). Because of the relatively large distances between reefs and the BOA, larval density in the BOA is likely to be near the lower range. Eggs, larvae, and planulae are not homogenously distributed but sometimes travel in semi-coherent aggregations (slicks) or become concentrated along oceanic fronts (Hughes et al. 2000; Jones et al. 2009). It is extremely unlikely that these shallow-water reef-associated larvae would occur in spent motor drop zones in the BOA because they are so far up current from sources of larvae. Larval density in the deep ocean waters near USAKA are likely to be near the lower range except during peak spawning when density may approach the upper range.

Summary of Corals in the Vicinity of Illeginni Islet. There are 22 species of coral requiring consultation that have been found in the vicinity of Illeginni Islet since 2010 (Table 4-7). Four of these species, *Acropora tenella, A. vaughani, Leptoseris incrustans,* and *Pavona cactus*, occur on lower reef slopes which occur well below areas that may be affected by the Action, and for this reason, adults will not be adversely affected by the Action. Two other species are only known to occur in Illeginni harbor, *Pavona decussata* and *Turbinaria mesenterina* and are not known or expected to be near the impact zone on Illeginni Islet. Adults of these species are not expected to be exposed to stressors related to the payload impact. A recent assessment by NMFS of the area that has the potential to be exposed to direct contact from payload impacts (NMFS-PIRO 2017a) reported colonies of seven coral species (*Acropora microclados, A. polystoma, Cyphastrea agassizi, Heliopora coerulea, Pavona venosa, Pocillopora meandrina,* and *Turbinaria reniformis*).

All shallow-water corals of the Marshall Islands are found throughout much of the insular Pacific and the coral triangle (i.e., the area surrounding Indonesia and the Philippines; Sakashita and Wolf 2009). No known shallow-water coral species are endemic to the Marshall Islands. Within Kwajalein Atoll, all coral species found at Illeginni Islet in NMFS/USFWS biennial inventories are found on at least one other Kwajalein Atoll islet (n = 11 islets; Table 4-7) and at other locations in the Marshall Islands (Beger et al. 2008; Pinca et al. 2002; USFWS and NMFS 2012). The waters offshore of Illeginni may support planktonic larvae of corals with similar characteristics as discussed above in the reproduction and deep-water sections.

Generally, coral cover and diversity at Illeginni Islet are moderate to high on the lagoon reef slopes and around to the southern and western seaward reef crest and slopes, while abundance and diversity appear lower off the seaward northwestern side of the islet. Near the Illeginni impact area, deeper ocean-side habitats (up to 4 m or 13 ft) include raised limestone plateaus which are highly colonized by corals separated by deep coral and cobble valleys (NMFS-PIRO 2017a). Shallower ocean-side habitats include areas with high coral colonization as well as an area that is primarily pavement and cobble with small patches of coral (NMFS-PIRO 2017a). Habitats on the lagoon-side of the impact area have less coral cover, mostly consisting of small scattered coral aggregates with some large patches of *Montipora digitata* (NMFS-PIRO 2017a). Illeginni harbor has a sandy bottom with dense seagrass beds but supports a diversity of coral species on both the wall and bottom habitats including nine consultation coral species.

Coral bleaching has been observed across Kwajalein Atoll in recent years. The NMFS observed a considerable amount of coral bleaching across the atoll between 2014 and 2016 (NMFS-PIRO 2017a). The majority of coral bleaching observed seemed to correlate with regional elevation in ocean temperatures during that time period (NMFS-PIRO 2017a). The pattern or bleaching across Kwajalein Atoll was scattered and inconsistent both in terms of species affected and spatial distribution of bleached corals (NMFS-PIRO 2017a). While there was evidence of coral bleaching within the area potentially affected by payload impacts at Illeginni Islet, there is no evidence that there were losses of entire species assemblages or total geographic losses across Kwajalein Atoll (NMFS-PIRO 2017a).

Table 4-7
Number of Survey Sites (2010 to present) with Observed Coral Consultation Species Occurrences at USAKA Islets (RN = Roi-Namur, ET = Ennugarett, GA = Gagan, GL = Gellinam, OM = Omelek, EK = Eniwetak, MK = Meek, IL = Illeginni, LG = Legan, EN = Ennylabegan, KI = Kwajalein) and Mid-Atoll Corridor (MAC).[1]

Family Scientific Name	RN	ET	GA	GL	OM	EK	MK	IL	LG	EN	KI	MAC	Total	# of Islets
Acroporidae														
Acropora aculeus	-	-	-	2	-	1	-	**1**	2	1	3	3	13	6
A. aspera	4	3	1	1	2	-	2	**1**	1	-	9	1	25	9
A. dendrum	-	-	1	1	2	2	4	**1**	1	1	7	5	25	9
A. listeri	-	-	1	1	-	1	2	**-**	1	-	2	2	10	6
A. microclados	3	3	4	6	6	5	8	**5**	7	5	16	34	102	11
A. polystoma	1	-	2	1	-	-	1	**-**	1	-	3	1	10	6
A. speciosa	-	1	-	-	-	-	2	**-**	-	-	4	4	11	3
A. tenella	1	-	-	-	-	-	1	**1**	-	1	5	1	10	5
A. vaughani	2	3	3	3	2	1	2	**2**	-	-	7	4	29	9
Montipora caliculata	2	4	2	7	5	4	8	**5**	6	2	6	31	82	11
Agariciidae														
Leptoseris incrustans	3	2	-	4	2	1	2	**2**	2	1	5	25	49	10
Pavona cactus	2	3	3	1	3	-	4	**2**	-	-	10	4	32	8
P. decussata	1	-	-	-	-	-	1	**1**	-	2	1	1	7	5
P. venosa	1	1	3	1	1	1	2	**2**	2	3	7	16	40	11
Dendrophylliidae														
Turbinaria mesenterina	1	-	1	-	1	-	-	**1**	1	-	-	-	5	5
T. reniformis	4	3	2	4	2	3	1	**4**	2	1	2	9	37	11
T. stellulata	3	2	1	1	-	-	-	**3**	1	-	-	9	20	6
Faviidae														
Cyphastrea agassizi	-	2	1	1	4	2	4	**3**	2	-	2	14	35	9
Helioporidae														
Heliopora coerulea	3	2	1	6	4	5	5	**4**	7	2	5	32	76	11
Mussidae														
Acanthastrea brevis	2	-	2	-	1	1	3	**4**	5	2	4	23	47	9
Pocilloporidae														
Pocillopora meandrina	11	5	5	8	7	5	8	**5**	7	5	19	35	120	11
Portidae														
Alveopora verrilliana	-	-	-	1	-	-	-	**2**	1	-	2	10	16	4
Total No. Sites Surveyed	**13**	**8**	**5**	**8**	**7**	**5**	**8**	**5**	**7**	**5**	**19**	**35**	**125**	**11**

[1]Sources: USFWS and NMFS 2012, NMFS and USFWS 2013a, NMFS and USFWS 2017, NMFS and USFWS 2018

4.5.1 *Acanthastrea brevis*

Species Description. *Acanthastrea brevis* is listed as vulnerable by the IUCN (IUCN 2015). This species was proposed for ESA listing in 2012 but was subsequently removed from the proposal after NMFS determined that listing it was unwarranted in August 2014; however, it is currently protected under the UES (USASMDC/ARSTRAT 2018 Section 3-4.5.1). This is a uniform or mottled brown, yellow, or green hard coral species in the family Mussidae with a spiny appearance (IUCN Species Account). This species is generally not fleshy and colonies are mostly submassive (IUCN Species Account).

Distribution. *Acanthastrea brevis* is found in the Red Sea and Gulf of Aden, the Southwest Indian Ocean, Northern Indian Ocean, the Central Indo-Pacific, the Oceanic West Pacific, the Great Barrier

Reef, and Fiji (IUCN Species Account). This range includes the US-affiliated waters of American Samoa, Micronesia, the Northern Mariana Islands, and Palau (Sakashita and Wolf 2009). *Acanthastrea brevis* is found in all types of reef habitat at depths of 1 to 20 m (3 to 66 ft; IUCN Species Account).

Threats. This species is particularly susceptible to crown-of-thorns starfish, which is a significant threat to many corals throughout the Indo-Pacific (IUCN Species Account). Due to this and other general coral threats listed above, this species is declining and has an estimated reduction in habitat of 36% over 30 years (IUCN Species Account).

Populations in the Action Area.
Broad Ocean Area: Adults do not occur in the BOA. Gametes and larvae may occur at very low densities in the BOA. See general description of coral occurrence in the BOA in Section 4.5.

Vicinity of Illeginni Islet: *Acanthastrea brevis* has been observed at 6 of the 11 surveyed Kwajalein Atoll islets since 2010 (Table 4-7). In addition to Illeginni Islet, it has been observed during inventories at Kwajalein, Roi-Namur, Meck, Gagan, and Eniwetak islets as well as on reefs in the Mid-Atoll Corridor. Overall, *A. brevis* has been observed at 38% (47 of 125) of survey sites in Kwajalein Atoll. This species was observed at 60% (4 of 5) of sites at Illeginni Islet since 2010 including a site in Illeginni harbor.

4.5.2 *Acropora aculeus*

Species Description. *Acropora aculeus* is listed as vulnerable by the IUCN (IUCN 2015). This species was proposed for ESA listing in 2012 but was subsequently removed from the proposal after NMFS determined that listing it was unwarranted in August 2014; however, it is currently protected under the UES (USASMDC/ARSTRAT 2018 Section 3-4.5.1). This species in the family Acroporidae is a gray, bright blue-green, or yellow hard coral species with tips that are yellow, lime green, pale blue, or brown (IUCN Species Account). *Acropora aculeus* forms colonies of corymbose clumps with thin, spreading horizontal branches and fine, upward projecting branchlets (Sakashita and Wolf 2009).

Distribution. *Acropora aculeus* is found throughout the central Indo-Pacific and is present, but not common in the Southwest, Northern, and Eastern Indian Ocean, Australia, Southeast Asia, Japan and the East China Sea, and the Oceanic West Pacific (IUCN Species Account). This range includes the US-affiliated waters of American Samoa, Micronesia, the Northern Mariana Islands, the Marshall Islands, and Palau (Sakashita and Wolf 2009). *Acropora aculeus* is found in reef slopes and lagoons at depths of 5 to 35 m (16 to 115 ft; IUCN Species Account).

Threats. This species is particularly susceptible to crown-of-thorns starfish, which is a serious threat to many corals throughout the Indo-Pacific (IUCN Species Account). Like other *Acropora* species, *A. aculeus* is susceptible to bleaching and disease and is slow to recover (IUCN Species Account). Aquarium harvest and extensive habitat reduction are also significant threats to this species (IUCN Species Account). Due to these and other general coral threats listed above, this species is declining and has an estimated habitat loss and population reduction of 37% over 30 years (IUCN Species Account).

Populations in the Action Area.
Broad Ocean Area: Adults do not occur in the BOA. Gametes and larvae may occur at very low densities in the BOA. See general description of coral occurrence in the BOA in Section 4.5.

Vicinity of Illeginni Islet: *Acropora aculeus* has been observed at 6 of the 11 surveyed Kwajalein Atoll islets since 2010 (Table 4-7). In addition to Illeginni, it has been observed during inventories at Kwajalein, Ennylabegan, Eniwetak, Gellinam, and Legan islets as well as on reefs in the Mid-Atoll Corridor. Overall, *A. aculeus* has been observed at 10% (13 of 125) survey sites in Kwajalein Atoll. This species was observed at 20% (1 of 5) of sites at Illeginni Islet since 2010.

4.5.3 *Acropora aspera*

Species Description. *Acropora aspera* is listed as vulnerable by the IUCN (IUCN 2015). This species was proposed for ESA listing in 2012 but was subsequently removed from the proposal after NMFS determined that listing it was unwarranted in August 2014; however, it is currently protected under the UES (USASMDC/ARSTRAT 2018 Section 3-4.5.1). This species in the family Acroporidae is a pale blue-gray, green, cream, or bright blue species found in thick-branching corymbose colonies that vary in length due to wave action (Sakashita and Wolf 2009).

Distribution. *Acropora aspera* is uncommon but found throughout the Northern Indian Ocean, the Central Indo-Pacific, Australia, Japan and the East China Sea, and the Oceanic West Pacific (IUCN Species Account). This range includes the US-affiliated waters of American Samoa, Micronesia, the Northern Mariana Islands, the Marshall Islands, and Palau (Sakashita and Wolf 2009). *Acropora aspera* is found on reef flats, shallow lagoons, and exposed upper reef slopes at depths up to 5 m (16 ft; IUCN Species Account).

Threats. This species is particularly susceptible to crown-of-thorns starfish, which is a serious threat to many corals throughout the Indo-Pacific (IUCN Species Account). Like other *Acropora* species, *A. aspera* is susceptible to bleaching and disease and is slow to recover (IUCN Species Account). Aquarium harvest and extensive habitat reduction and degradation are also significant threats to this species (IUCN Species Account). Due to these and other general coral threats listed above, this species is declining and has an estimated habitat loss of 37% over 30 years (IUCN Species Account).

Populations in the Action Area.
Broad Ocean Area: Adults do not occur in the BOA. Gametes and larvae may occur at very low densities in the BOA. See general description of coral occurrence in the BOA in Section 4.5.

Vicinity of Illeginni Islet: *Acropora aspera* has been observed at 9 of the 11 surveyed Kwajalein Atoll islets since 2010 as well as on reefs in the Mid-Atoll Corridor (Table 4-7). This species has been observed only in harbor surveys at Illeginni islet (20% of sites, 1 of 5 sites). Overall, *A. aspera* has been observed at 20% (25 of 125) survey sites in Kwajalein Atoll since 2010.

4.5.4 *Acropora dendrum*

Species Description. *Acropora dendrum* is listed as vulnerable by the IUCN (IUCN 2015). This species was proposed for ESA listing in 2012 but was subsequently removed from the proposal after NMFS determined that listing it was unwarranted in August 2014; however, it is currently protected under the UES (USASMDC/ARSTRAT 2018 Section 3-4.5.1). This species in the family Acroporidae is a pale brown or cream colored hard coral species (IUCN Species Account). *Acropora dendrum* forms colonies of corymbose plates that are 0.5 to 1 m (1.6 to 3.3 ft) across and have widely spaced, tapering branchlets (Sakashita and Wolf 2009).

Distribution. *Acropora dendrum* is uncommon throughout the Northern Indian Ocean, Central Indo-Pacific, Australia, Southeast Asia, Japan and the East China Sea, and the Oceanic West Pacific (IUCN Species Account). This range includes the US-affiliated waters of American Samoa, Micronesia, the Marshall Islands, and Palau (Sakashita and Wolf 2009). *Acropora dendrum* is found on upper reef slopes at depths of 5 to 20 m (16 to 66 ft; IUCN Species Account).

Threats. This species is particularly susceptible to crown-of-thorns starfish, which is a serious threat to many corals throughout the Indo-Pacific (IUCN Species Account). Like other *Acropora* species, *A. dendrum* is susceptible to bleaching and disease and is slow to recover (IUCN Species Account). Aquarium harvest and extensive habitat reduction and degradation are also significant threats to this species (IUCN Species Account). Due to these and other general coral threats listed above, this species is declining and has an estimated habitat loss and population reduction of 35% over 30 years (IUCN Species Account).

Populations in the Action Area.
Broad Ocean Area: Adults do not occur in the BOA. Gametes and larvae may occur at very low densities in the BOA. See general description of coral occurrence in the BOA in Section 4.5.

Vicinity of Illeginni Islet: *Acropora dendrum* has been observed at 9 of the 11 surveyed Kwajalein Atoll islets since 2010 (Table 4-7). In addition to Illeginni, it has been observed during inventories at Kwajalein, Meck, Omelek, Legan, Gagan, Eniwetak, Ennylabegan, and Gellinam islets as well as on reefs in the Mid-Atoll Corridor. Overall, *A. dendrum* has been observed at 20% (25 of 125) survey sites in Kwajalein Atoll. This species was observed at 20% (1 of 5) of sites at Illeginni Islet since 2010 (Table 4-7).

4.5.5 *Acropora listeri*

Species Description. *Acropora listeri* is listed as vulnerable by the IUCN (IUCN 2015). This species was proposed for ESA listing in 2012 but was subsequently removed from the proposal after NMFS determined that listing it was unwarranted in August 2014; however, it is currently protected under the UES (USASMDC/ARSTRAT 2018 Section 3-4.5.1). This species in the family Acroporidae is a cream or brown colored hard coral species (IUCN Species Account). *Acropora listeri* forms colonies of irregular clumps or corymbose plates with thick, highly irregular branches that may vary in form depending on wave action (Sakashita and Wolf 2009).

Distribution. *Acropora listeri* is found throughout the Northern Indian Ocean, Central Indo-Pacific, Australia, Southeast Asia, Japan and the East China Sea, the Oceanic West Pacific, the Central Pacific and Mauritius (IUCN Species Account). This range includes the US-affiliated waters of American Samoa, Micronesia, the Marshall Islands, the Northern Mariana Islands, and Palau (Sakashita and Wolf 2009). *Acropora listeri* is found on upper reef slopes at depths of 3 to 15 m (10 to 49 ft; IUCN Species Account).

Threats. This species is particularly susceptible to crown-of-thorns starfish, which is a serious threat to many corals throughout the Indo-Pacific (IUCN Species Account). Like other *Acropora* species, *A. listeri* is susceptible to bleaching and disease and is slow to recover from disturbance events (IUCN Species Account). Aquarium harvest and extensive habitat reduction and degradation are also significant threats to this species (IUCN Species Account). Due to these and other general coral threats listed above, this species is declining and has an estimated habitat loss and population reduction of 35% over 30 years (IUCN Species Account).

Populations in the Action Area.
Broad Ocean Area: Adults do not occur in the BOA. Gametes and larvae may occur at very low densities in the BOA. See general description of coral occurrence in the BOA in Section 4.5.

Vicinity of Illeginni Islet: *Acropora listeri* has been observed at all 6 of the 11 surveyed Kwajalein Atoll islets since 2010 and on reefs in the Mid-Atoll Corridor (Table 4-7). While the species has not been observed at Illeginni islet, it has been observed near Legan, Gagan, Gellinam, Meck, Kwajalein, and Eniwetak islets. Overall, *A. listeri* has been observed at 8% (25 of 125) survey sites in Kwajalein Atoll since 2010 (Table 4-7).

4.5.6 *Acropora microclados*

Species Description. *Acropora microclados* is listed as vulnerable by the IUCN (IUCN 2015). This species was proposed for ESA listing in 2012 but was subsequently removed from the proposal after NMFS determined that listing it was unwarranted in August 2014; however, it is currently protected under the UES (USASMDC/ARSTRAT 2018 Section 3-4.5.1). This species in the family Acroporidae is a pale pinkish-brown colored hard coral species with pale gray tentacles (IUCN Species Account). *Acropora microclados* forms colonies of corymbose plates that are up to 1 m (3.3 ft) across and have short, uniform, tapered branchlets that are up to 10 mm (0.4 in) thick at their bases (Sakashita and Wolf 2009).

Distribution. *Acropora microclados* is found throughout the Red Sea and Gulf of Aden, the Northern Indian Ocean, Central Indo-Pacific, Australia, Southeast Asia, Japan and the East China Sea, the Oceanic West Pacific, Samoa, the Cook Islands, and the Chagos Archipelago (IUCN Species Account). This range includes the US-affiliated waters of American Samoa, Micronesia, the Marshall Islands, and Palau (Sakashita and Wolf 2009). *Acropora microclados* is found on upper reef slopes at depths of 5 to 20 m (16 to 66 ft; IUCN Species Account).

Threats. This species is particularly susceptible to crown-of-thorns starfish, which is a serious threat to many corals throughout the Indo-Pacific (IUCN Species Account). Like other *Acropora* species, *A. microclados* is susceptible to bleaching and disease and is slow to recover (IUCN Species Account). Aquarium harvest and extensive habitat reduction and degradation are also significant threats to this species (IUCN Species Account). Due to these and other general coral threats listed above, this species is declining and has an estimated habitat loss and population reduction of 33% over 30 years (IUCN Species Account).

Populations in the Action Area.
Broad Ocean Area: Adults do not occur in the BOA. Gametes and larvae may occur at very low densities in the BOA. See general description of coral occurrence in the BOA in Section 4.5.

Vicinity of Illeginni Islet: *Acropora microclados* has been observed at all 11 of the surveyed Kwajalein Atoll islets since 2010 and on reefs in the Mid-Atoll Corridor (Table 4-7). Overall, *A. microclados* has been observed at 82% (102 of 125) survey sites in Kwajalein Atoll. This species was observed at 100% (5 of 5) of sites at Illeginni Islet since 2008 (Table 4-7) including in Illeginni harbor.

4.5.7 *Acropora polystoma*

Species Description. *Acropora polystoma* is listed as vulnerable by the IUCN (IUCN 2015). This species was proposed for ESA listing in 2012 but was subsequently removed from the proposal after NMFS determined that listing it was unwarranted in August 2014; however, it is currently protected under the UES (USASMDC/ARSTRAT 2018 Section 3-4.5.1). This species in the family Acroporidae is a cream, blue, or yellow colored hard coral species (IUCN Species Account). *Acropora polystoma* forms colonies of irregular clumps or corymbose plates with tapered, uniform branches (Sakashita and Wolf 2009).

Distribution. *Acropora polystoma* is an uncommon species found throughout the Red Sea and the Gulf of Aden, the Southwest and Northern Indian Ocean, the Central Indo-Pacific, Australia, Southeast Asia, Japan, the Oceanic West Pacific, Samoa, and the Cook Islands (IUCN Species Account). This range includes the US-affiliated waters of American Samoa, Micronesia, the Marshall Islands, and Palau (Sakashita and Wolf 2009). *Acropora polystoma* is found in tropical reef-edge habitats at depths of 3 to 10 m (9.8 to 33 ft) including upper reef slopes exposed to strong wave action (IUCN Species Account).

Threats. This species is particularly susceptible to crown-of-thorns starfish, which is a serious threat to many corals throughout the Indo-Pacific (IUCN Species Account). Like other *Acropora* species, *A. polystoma* is susceptible to bleaching and disease and is slow to recover (IUCN Species Account). Aquarium harvest and extensive habitat reduction and degradation are also significant threats to this species (IUCN Species Account). This species has also been reported to have severe white-band/white-plague disease, which affects reproduction and can have devastating regional impacts. Due to these and other general coral threats listed above, this species is declining and has an estimated habitat loss and population reduction of 35% over 30 years (IUCN Species Account).

Populations in the Action Area.
<u>*Broad Ocean Area*</u>*:* Adults do not occur in the BOA. Gametes and larvae may occur at very low densities in the BOA. See general description of coral occurrence in the BOA in Section 4.5.

<u>*Vicinity of Illeginni Islet*</u>*:* *Acropora polystoma* has been observed at 6 of the 11 Kwajalein Atoll islets and on reefs in the Mid-Atoll Corridor since 2010. Though not observed during surveys at Illeginni islet, this species has been observed near Kwajalein, Legan, Meck, Gellinam, Gagan, and Roi Namur islets. Overall, *A. polystoma* has been observed at 8% (10 of 125) survey sites in Kwajalein Atoll (Table 4-7).

4.5.8 *Acropora speciosa*

Species Description. *Acropora speciosa* was listed as a threatened species under the ESA in August 2014 and is listed as vulnerable by the IUCN (IUCN 2015). This species in the family Acroporidae has cream-colored colonies consisting of thick cushions and bottlebrush branches with contrasting corallite tips (Sakashita and Wolf 2009).

Distribution. *Acropora speciosa* occurs in the Central Indo-Pacific, Australia, Southeast Asia, the Central Pacific, New Caledonia, the Philippines, Fiji, Sarawak, Ban Ngai, Papua New Guinea, Western Samoa, and the Oceanic West Pacific (IUCN Species Account). This range includes the US-affiliated waters of American Samoa, the Marshall Islands, Micronesia, and Palau (Sakashita and Wolf 2009). *Acropora speciosa* is found in protected reef environments with clear water and high *Acropora* diversity and also occurs subtidally on walls and steep slopes in deep or shaded shallow conditions (IUCN

Species Account). This species is typically found at depths of 12 to 30 m (39 to 98 ft; IUCN Species Account).

Threats. This species exhibits a decreasing population trend and like other *Acropora* species, *A. speciosa* is particularly susceptible to bleaching, disease, crown-of-thorns starfish predation, trade, and habitat degradation (IUCN Species Account). Due to these and other general coral threats listed above, this species is declining and has an estimated habitat loss and population reduction of 35% over 30 years (IUCN Species Account).

Populations in the Action Area.
Broad Ocean Area: Adults do not occur in the BOA. Gametes and larvae may occur at very low densities in the BOA. See general description of coral occurrence in the BOA in Section 4.5.

Vicinity of Illeginni Islet: *Acropora speciosa* has been observed at 3 of the 11 surveyed Kwajalein Atoll islets since 2010 and has also been observed at sites in the Mid-Atoll Corridor (Table 4-7). Overall, *A. speciosa* has been observed at only 9% (11 of 125) survey sites in Kwajalein Atoll. This species was not observed at biennial survey sites at Illeginni Islet since 2010. Since *A. speciosa* is a deeper dwelling species, it occurs below areas that have the potential to be affected by the Action in the vicinity of Illeginni islet.

4.5.9 *Acropora tenella*

Species Description. *Acropora tenella* was listed as a threatened species under the ESA in August 2014 and is listed as vulnerable by the IUCN (IUCN 2015). This species in the family Acroporidae has colonies consisting of horizontal plates or flattened branches with white or blue tips that either fan out or form irregular tangles (Sakashita and Wolf 2009).

Distribution. *Acropora tenella* is common in some areas throughout the Central Indo-Pacific, Australia, Southeast Asia, Japan and the East China Sea, and the Oceanic West Pacific (IUCN Species Account). This range includes the US-affiliated waters of the Northern Mariana Islands, Micronesia, and Palau (Sakashita and Wolf 2009). *Acropora tenella* is found on lower reef slopes below 40 m (131 ft) and on subtidal, protected slopes and shelves at depths of 25 to 70 m (82 to 246 ft; IUCN Species Account).

Threats. This species is particularly susceptible to crown-of-thorns starfish, which is a serious threat to many corals throughout the Indo-Pacific (IUCN Species Account). Like other *Acropora* species, *A. tenella* is susceptible to bleaching and disease and is slow to recover (IUCN Species Account). Aquarium harvest and extensive habitat reduction and degradation are also significant threats to this species (IUCN Species Account). Due to these and other general coral threats listed above, this species is declining and has an estimated habitat loss and population reduction of 39% over 30 years (IUCN Species Account).

Populations in the Action Area.
Broad Ocean Area: Adults do not occur in the BOA. Gametes and larvae may occur at very low densities in the BOA. See general description of coral occurrence in the BOA in Section 4.5.

Vicinity of Illeginni Islet: *Acropora tenella* has been observed at 2 of the 11 Kwajalein Atoll islets since 2008. In addition to Illeginni Islet, it has been observed during inventories at Kwajalein Islet and on reefs in the Mid-Atoll Corridor. Overall, *A. tenella* has been observed at only 7% (7 of 95) survey sites in Kwajalein Atoll. This species was observed at 25% (1 of 4) of sites at Illeginni Islet since 2008. However, since *A. tenella i*s a deeper dwelling species, it occurs below areas that have the potential to be affected by the Action in the vicinity of Illeginni Islet.

4.5.10 *Acropora vaughani*

Species Description. *Acropora vaughani* is listed as vulnerable by the IUCN (IUCN 2015). This species was proposed for ESA listing in 2012 but was subsequently removed from the proposal after NMFS determined that listing it was unwarranted in August 2014; however, it is currently protected under the UES (USASMDC/ARSTRAT 2018 Section 3-4.5.1). This species in the family Acroporidae is a blue, cream, or pale brown colored hard coral species (IUCN Species Account). This species forms open branched colonies with a bushy appearance due to compact branchlets protruding from the main branches (Sakashita and Wolf 2009).

Distribution. *Acropora vaughani* is uncommon but found throughout the Northern Indian Ocean, Central Indo-Pacific, Australia, Southeast Asia, Japan and the East China Sea, the Oceanic West Pacific, the Central Pacific, and Madagascar (IUCN Species Account). This range includes the US-affiliated waters of American Samoa, Micronesia, the Marshall Islands, the Northern Mariana Islands and Palau (Sakashita and Wolf 2009). *Acropora vaughani* is restricted to protected subtidal habitats such as contained lagoons and sandy slopes in turbid waters around fringing reefs at depths of 3 to 20 m (10 to 66 ft; IUCN Species Account).

Threats. This species is particularly susceptible to crown-of-thorns starfish, which is a serious threat to many corals throughout the Indo-Pacific (IUCN Species Account). Like other *Acropora* species, *A. vaughani* is susceptible to bleaching and disease and is slow to recover (IUCN Species Account). Aquarium harvest and extensive habitat reduction and degradation are also significant threats to this species (IUCN Species Account). Due to these and other general coral threats listed above, this species is declining and has an estimated habitat loss and population reduction of 35% over 30 years (IUCN Species Account).

Populations in the Action Area.
Broad Ocean Area: Adults do not occur in the BOA. Gametes and larvae may occur at very low densities in the BOA. See general description of coral occurrence in the BOA in Section 4.5.

Vicinity of Illeginni Islet: *Acropora vaughani* has been observed at 9 of the 11 surveyed Kwajalein Atoll islets since 2010 (Table 4-7). In addition to Illeginni, it has been observed during inventories at Kwajalein, Roi-Namur Omelek, Gagan, Gellinam, Eniwetak, Meck, and Ennugarett islets as well as on reefs in the Mid-Atoll Corridor. Overall, *A. vaughani* has been observed at 23% (29 of 125) survey sites in Kwajalein Atoll. This species was observed at 40% (2 of 5) of sites at Illeginni Islet since 2010 including during surveys of Illeginni harbor (Table 4-7). However, since *A. vaughani i*s a deeper dwelling species, it occurs below the areas that have the potential to be affected by the Action in the vicinity of Illeginni islet.

4.5.11 *Alveopora verrilliana*

Species Description. *Alveopora verrilliana* is listed as vulnerable by the IUCN (IUCN 2015). This species was proposed for ESA listing in 2012 but was subsequently removed from the proposal after NMFS determined that listing it was unwarranted in August 2014; however, it is currently protected under the UES (USASMDC/ARSTRAT 2018 Section 3-4.5.1). This species in the family Acroporidae is a dark greenish-brown, gray, or chocolate brown colored hard coral species (IUCN Species Account). *Alveopora verrilliana* forms hemispherical colonies with short, irregularly dividing, knob-like branches (Sakashita and Wolf 2009).

Distribution. *Alveopora verrilliana* is uncommon but found in the Red Sea and Gulf of Aden, the Northern Indian Ocean, Central Indo-Pacific, Australia, Southeast Asia, Japan and the East China Sea, the Oceanic West Pacific, the Central Pacific, and the Southern Mariana Islands (IUCN Species Account). This range includes the US-affiliated waters of American Samoa, Micronesia, the Marshall Islands, the Northern Mariana Islands, Palau, and Johnston Atoll (Sakashita and Wolf 2009). This species is found in reef environments at depths of up to 30 m (98 ft; IUCN Species Account).

Threats. Like other *Alveopora* species, *A. verrilliana* is susceptible to bleaching and harvest for the aquarium trade (IUCN Species Account). Due to these and other general coral threats listed above, this species has an estimated habitat loss and population reduction of 35% over 30 years, however, recent population trends are unknown (IUCN Species Account).

Populations in the Action Area.
Broad Ocean Area: Adults do not occur in the BOA. Gametes and larvae may occur at very low densities in the BOA. See general description of coral occurrence in the BOA in Section 4.5.

Vicinity of Illeginni Islet: *Alveopora verrilliana* has been observed at 4 of the 11 surveyed Kwajalein Atoll islets since 2010 (Table 4-7). In addition to Illeginni, it has been observed during inventories at Kwajalein, Gellinam, and Legan islets as well as on reefs in the Mid-Atoll Corridor. Overall, *A. verrilliana* has been observed at 13% (16 of 125) survey sites in Kwajalein Atoll. This species was observed at 40% (2 of 5) of sites at Illeginni Islet since 2010 (Table 4-7).

4.5.12 *Cyphastrea agassizi*

Species Description. *Cyphastrea agassizi* is listed as vulnerable by the IUCN (IUCN 2015). This species was proposed for ESA listing but was subsequently removed from the proposal after NMFS determined that listing it was unwarranted; however, it is currently protected under the UES (USASMDC/ARSTRAT 2018 Section 3-4.5.1). This species in the family Faviidae is a pale brown or green colored coral species (IUCN Species Account). This species forms massive colonies that are only a few inches in diameter with deeply grooved surfaces and widely spaced corallites (Sakashita and Wolf 2009).

Distribution. *Cyphastrea agassizi* is uncommon but found in shallow reef environments of the Andaman Sea, the Central Indo-Pacific, Australia, Southeast Asia, Japan and the East China Sea, the Oceanic West Pacific, and Fiji (IUCN Species Account). This range includes the Hawaiian Islands and the US-affiliated waters of, Johnston Atoll, Micronesia, the Northern Mariana Islands, and Palau (Sakashita and Wolf 2009). *Cyphastrea agassizi* occurs in shallow reef environments including back slopes, foreslopes, and lagoons as well as in the outer reef channel at depths of up to 20 m (66 ft; IUCN Species Account).

Threats. This species is particularly susceptible to bleaching, disease, and habitat reduction throughout its range (IUCN Species Account). Due to these and other general coral threats listed above, this species is declining and has an estimated habitat loss and population reduction of 36% over 30 years (IUCN Species Account).

Populations in the Action Area.
Broad Ocean Area: Adults do not occur in the BOA. Gametes and larvae may occur at very low densities in the BOA. See general description of coral occurrence in the BOA in Section 4.5.

Vicinity of Illeginni Islet: *Cyphastrea agassizi* has been observed at 9 of the 11 surveyed Kwajalein Atoll islets since 2010 as well as on reefs in the Mid-Atoll Corridor (Table 4-7). Overall, *C. agassizi* has been observed at 28% (35 of 125) survey sites in Kwajalein Atoll. This species was observed at 60% (3 of 5) of sites at Illeginni Islet since 2010 including in Illeginni harbor in 2014 (Table 4-7).

4.5.13 *Heliopora coerulea*

Species Description. *Heliopora coerulea* is listed as vulnerable by the IUCN (IUCN 2015). This species was proposed for ESA listing but was subsequently removed from the proposal after NMFS determined that listing it was unwarranted; however, it is currently protected under the UES (USASMDC/ARSTRAT 2018 Section 3-4.5.1). This species in the family Helioporidae is a blue or greenish stony, non-scleractinian coral species that has a permanently blue skeleton (IUCN Species Account). *Heliopora coerulea* has polyps with eight tentacles and demonstrates significant variability in growth form based on habitat (Sakashita and Wolf 2009).

Distribution. *Heliopora coerulea* is widespread in the Indo-Pacific from the Red Sea and East Africa to Southeast Asia and Polynesia, including Southern Japan, Australia, and the Coral Sea (IUCN Species Account). This range includes the US-affiliated waters of American Samoa, Micronesia, the Marshall Islands, and Palau (Sakashita and Wolf 2009). This species is found in very shallow (less than 2 m [7 ft]) reef flats and intertidal zones and in potentially deeper waters as well (IUCN Species Account).

Threats. This species is locally common, but the population is thought to be declining. *Heliopora coerulea* is particularly susceptible to harvest for curios, jewelry, and the aquarium trade and is also vulnerable to bleaching, local stochastic events, and habitat reduction (Sakashita and Wolf 2009). Due to these and other general coral threats listed above, this species has an estimated habitat loss and population reduction of 37% over 30 years (IUCN Species Account).

Populations in the Action Area.
Broad Ocean Area: Adults do not occur in the BOA. Gametes and larvae may occur at very low densities in the BOA. See general description of coral occurrence in the BOA in Section 4.5.

Vicinity of Illeginni Islet: *Heliopora coerulea* has been observed at all 11 of the surveyed Kwajalein Atoll islets since 2010 as well as on reefs in the Mid-Atoll Corridor. Overall, *H. coerulea* has been observed at 61% (76 of 125) survey sites in Kwajalein Atoll. This species was observed at 80% (4 of 5) of sites at Illeginni Islet since 2010 (Table 4-7).

4.5.14 *Leptoseris incrustans*

Species Description. *Leptoseris incrustans* is listed as vulnerable by the IUCN (IUCN 2015). This species was proposed for ESA listing but was subsequently removed from the proposal after NMFS determined that listing it was unwarranted; however, it is currently protected under the UES (USASMDC/ARSTRAT 2018 Section 3-4.5.1). *Leptoseris incrustans* is in the family Agariciidae and is a small, pale to dark brown or greenish-brown hard coral species (IUCN Species Account). Colonies of this species are usually encrusting, though sometimes they develop broad explanate laminae with radiating ridges (IUCN Species Account). This species also has small, compacted columellae and superficial corallites with a secondary radial symmetry (IUCN Species Account).

Distribution. *Leptoseris incrustans* is found in the Indo-West Pacific in the Red Sea, the Southwest and Central Indian Ocean, the Central Indo-Pacific, Southern Japan and the South China Sea, Eastern Australia, the Oceanic West Pacific, and the Central Pacific (IUCN Species Account). This range includes the US-affiliated waters of the Hawaiian Islands, Johnston Atoll, American Samoa, Micronesia, the Marshall Islands, the Northern Mariana Islands, and Palau (Sakashita and Wolf 2009). This species is found on reef slopes and vertical walls at depths of 10 to 20 m (33 to 66 ft; IUCN Species Account).

Threats. This species is an uncommon species with unknown population trends (IUCN Species Account). *Leptoseris incrustans* is susceptible to bleaching, disease, crown-of-thorns starfish predation, and reef habitat reduction (Sakashita and Wolf 2009). Due to these and other general coral threats listed above, this species has an estimated habitat loss and population reduction of 35% over 30 years (IUCN Species Account).

Populations in the Action Area.
Broad Ocean Area: Adults do not occur in the BOA. Gametes and larvae may occur at very low densities in the BOA. See general description of coral occurrence in the BOA in Section 4.5.

Vicinity of Illeginni Islet: *Leptoseris incrustans* has been observed at 10 of the 11 surveyed Kwajalein Atoll islets since 2010 as well as on reefs in the Mid-Atoll Corridor (Table 4-7). Overall, *L. incrustans* has been observed at 39% (49 of 125) survey sites in Kwajalein Atoll (Table 4-7). This species was observed during 40% (2 of 5) of biennial surveys at Illeginni Islet since 2010.

4.5.15 *Montipora caliculata*

Species Description. *Montipora caliculata* is listed as vulnerable by the IUCN (IUCN 2015). This species was proposed for ESA listing in 2012 but was subsequently removed from the proposal after NMFS determined that listing it was unwarranted in August 2014; however, it is currently protected under the UES (USASMDC/ARSTRAT 2018 Section 3-4.5.1). This species in the family Acroporidae is a brown or blue coral species (IUCN Species Account). *Montipora caliculata* forms massive colonies with a mixture of immersed and funnel-shaped corallites; the latter generally have wavy rims (Sakashita and Wolf 2009).

Distribution. *Montipora caliculata* is uncommon but found in Kenya, Tanzania, Northern Madagascar, the Andaman Islands, Thailand, Southeast Asia, the South China Sea, Southern Japan, Papua New Guinea, Australia, the Solomon Islands, Vanuatu, New Caledonia, Ogasawara Island, Samoa, Fiji, the Cook Islands, Kiribati, French Polynesia, and the Pitcairn Islands (IUCN Species Account). It is also found in the US-affiliated waters of Micronesia, the Marshall Islands, the Northern Mariana Islands and Palau (Sakashita and Wolf 2009). This species is found in most reef environments at depths of up to 20 m (66 ft) or more (IUCN Species Account).

Threats. *Montipora caliculata* is susceptible to bleaching, disease, crown-of-thorns starfish predation, and habitat degradation (Sakashita and Wolf 2009). Like other species in the *Montipora* genus, it is also vulnerable to heavy harvest levels (Sakashita and Wolf 2009). Due to these and other general coral threats listed above, this species is declining and has an estimated habitat loss and population reduction of 36% over 30 years (IUCN Species Account).

Populations in the Action Area.
Broad Ocean Area: Adults do not occur in the BOA. Gametes and larvae may occur at very low densities in the BOA. See general description of coral occurrence in the BOA in Section 4.5.

Vicinity of Illeginni Islet: *Montipora caliculata* has been observed at all 11 of the surveyed Kwajalein Atoll islets since 2010 as well as well as on reefs in the Mid-Atoll Corridor (Table 4-7). Overall, *M. caliculata* has been observed at 66% (82 of 125) survey sites in Kwajalein Atoll. This species was observed at 100% (5 of 5) of sites at Illeginni Islet since 2010 including in Illeginni harbor (Table 4-7).

4.5.16 *Pavona cactus*

Species Description. *Pavona cactus* is listed as vulnerable by the IUCN (IUCN 2015) and is protected by RMI statute (USASMDC/ARSTRAT 2018 Section 3-4.5.1). This species in the family Agariciidae is a pale brown or greenish-brown coral species with white margins (IUCN Species Account). *Pavona cactus* forms colonies with thin, contorted, bifacial, upright fronds with sometimes-thickened branching bases (Sakashita and Wolf 2009).

Distribution. *Pavona cactus* is found throughout the Red Sea and Gulf of Aden, the Persian and Arabian Gulfs, the Southwest and Central Indian Ocean, Central Indo-Pacific, Australia, Southern Japan and the South China Sea, the Oceanic West Pacific, and the Central Pacific (IUCN Species Account). This range includes the US-affiliated waters of American Samoa, Micronesia, the Marshall Islands, the Northern Mariana Islands and Palau (Sakashita and Wolf 2009). This species is found in lagoons and on upper reef slopes, especially those of fringing reefs, and in turbid water protected from wave action at depths of 3 to 20 m (10 to 66 ft; IUCN Species Account).

Threats. *Pavona cactus* is susceptible to bleaching, extensive reduction of reef habitat, and aquarium harvest (IUCN Species Account). Due to these and other general coral threats listed above, this species is declining and has an estimated habitat loss and population reduction of 36% over 30 years (IUCN Species Account).

Populations in the Action Area.
Broad Ocean Area: Adults do not occur in the BOA. Gametes and larvae may occur at very low densities in the BOA. See general description of coral occurrence in the BOA in Section 4.5.

Vicinity of Illeginni Islet: *Pavona cactus* has been observed at 8 of the 11 surveyed Kwajalein Atoll islets since 2010. In addition to Illeginni, it has been observed during inventories at Kwajalein, Roi Namur, Meck, Omelek, Gagan, Gellinam, and Ennugarett islets as well as on reefs in the Mid-Atoll Corridor. Overall, *Pavona cactus* has been observed at 26% (32 of 125) survey sites in Kwajalein Atoll. This species was observed at 40% (2 of 5) of sites at Illeginni Islet since 2010 including in Illeginni harbor (Table 4-7). However, since *A. vaughani* is a deeper dwelling species, it occurs below the areas that have the potential to be affected by the Action in the vicinity of Illeginni Islet.

4.5.17 *Pavona decussata*

Species Description. *Pavona decussata* is listed as vulnerable by the IUCN (IUCN 2018). This species was proposed for ESA listing but was subsequently removed from the proposal after NMFS determined that listing it was unwarranted (77 FR 73220 [December 7, 2012]). However, *P. decussata* is currently protected under the UES (USASMDC/ARSTRAT 2018 Section 3-4.5.1). *Pavona decussata* is in the family Agariciidae and is a brown, creamy-yellow, or greenish color coral with colonies that grow into thick, upright plates (Brainard et al. 2011). These variable shaped colonies can grow to several meters across (Sakashita and Wolf 2009).

Distribution. *Pavona decussata* has a global distribution from the Red Sea to French Polynesia and as far north as Japan south to the Western coasts of Australia and Madagascar (Brainard et al. 2011). This range includes the US-affiliated waters of American Samoa, the Marshall Islands, Micronesia, the Northern Mariana Islands, and Palau (Sakashita and Wolf 2009). *Pavona decussata* occurs most commonly in shallow reef environments at depths of 3 to 11 m (10 to 36 ft) and more rarely at depths of 12 to 15 m (39 to 49 ft; IUCN Species Account).

Threats. *Pavona decussata* is susceptible to bleaching, disease, ocean acidification, fisheries, and extensive reduction of reef habitat; however, its current population trend is unknown (IUCN Species Account). Due to these and other general coral threats listed above, this species has an estimated habitat loss and population reduction of 36% over 30 years (IUCN Species Account).

Populations in the Action Area.
<u>Broad Ocean Area</u>*:* Adults do not occur in the BOA. Gametes and larvae may occur at very low densities in the BOA. See general description of coral occurrence in the BOA in Section 4.5.

<u>Vicinity of Illeginni Islet</u>*:* *Pavona decussata* has been observed at 5 of the 11 surveyed Kwajalein Atoll islets since 2010 as well as or reefs in the Mid-Atoll Corridor (Table 4-7). In addition to Illeginni, *P. decussata* had been observed near Roi-Namur, Meck, Ennylabegan, and Kwajalein islets. Overall, *P. decussata* has been observed at 6% (7 of 125) survey sites in Kwajalein Atoll. At Illeginni Islet, this species was observed only at Illeginni harbor (20% of Illeginni sties) and is not known or expected to occur at reefs on the western end of Illeginni Islet.

4.5.18 *Pavona venosa*

Species Description. *Pavona venosa* is listed as vulnerable by the IUCN (IUCN 2015). This species was proposed for ESA listing but was subsequently removed from the proposal after NMFS determined that listing it was unwarranted; however, it is currently protected under the UES (USASMDC/ARSTRAT 2018 Section 3-4.5.1). *Pavona venosa* is in the family Agariciidae and is a yellowish- or pinkish-brown coral that is sometimes mottled (IUCN Species Account). This species forms massive to encrusting colonies that are generally less than 50 cm (20 in) in diameter with sunken corallites arranged in short valleys (Sakashita and Wolf 2009).

Distribution. *Pavona venosa* is uncommon but found in the Red Sea and Gulf of Aden, the Southwest, Northwest, and Central Indian Ocean, the Arabian/Iranian Gulf, Central Indo-Pacific, Tropical Australia, Southern Japan and the South China Sea, and the Oceanic West Pacific (IUCN Species Account). This range includes the US-affiliated waters of Micronesia, the Marshall Islands, the Northern Mariana Islands and Palau (Sakashita and Wolf 2009). *Pavona venosa* occurs in shallow reef environments at depths of 2 to 20 m (7 to 66 ft; IUCN Species Account).

Threats. *Pavona venosa* is susceptible to bleaching, disease, and extensive reduction of reef habitat; however, its current population trend is unknown (IUCN Species Account). Due to these and other general coral threats listed above, this species has an estimated habitat loss and population reduction of 37% over 30 years (IUCN Species Account).

Populations in the Action Area.
Broad Ocean Area: Adults do not occur in the BOA. Gametes and larvae may occur at very low densities in the BOA. See general description of coral occurrence in the BOA in Section 4.5.

Vicinity of Illeginni Islet: *Pavona venosa* has been observed at all 11 of the surveyed Kwajalein Atoll islets since 2010 as well as on reefs in the Mid-Atoll Corridor (Table 4-7). Overall, *P. venosa* has been observed at 32% (40 of 125) survey sites in Kwajalein Atoll. This species was observed at 40% (2 of 5) of sites at Illeginni Islet since 2010 (Table 4-7).

4.5.19 *Pocillopora meandrina*

Species Description. *Pocillopora meandrina* is listed as a species of "least concern" by the IUCN (IUCN 2015). The Center for Biological Diversity petitioned the NMFS to list the cauliflower coral in Hawai`i as endangered or threatened under the ESA in March 2018 (CBD 2018). In September 2018, NMFS found that *P. meandrina* may warrant listing under the ESA (83 FR 47592 [September 20, 2018]). This species is now a candidate for listing under the ESA and is therefore protected under the UES. *Pocillopora meandrina* is in the family Pocilloporidae. This hard coral species forms small upright bushes up to 30 cm in diameter that are cream, green, or pink in color (CBD 2018). Colonies form flattened branches that uniformly radiate out from the original growth point (CBD 2018). This species has a relatively fast growth rate with high recruitment; however, colonies may also be short lived due to recolonization by other coral species and high sensitivity to disturbance (CBD 2018).

Distribution. *Pocillopora meandrina* is found throughout tropical and subtropical Indian and Pacific oceans in shallow reefs (CBD 2018). This range includes Hawai`i, Johnston Atoll, American Samoa, the Marshall Islands, Micronesia, the Northern Mariana Islands, and Palau among other island groups (CBD 2018). *Pocillopora meandrina* occurs in shallow reef environments with high wave energy at depths of 1 to 27 m (3 to 89 ft; CBD 2018).

Threats. Major threats to *Pocillopora meandrina* include destruction and/or modification of habitat, harvest for the aquarium trade, disease, predation, and high susceptibility to bleaching due to thermal stress (CBD 2018). During a bleaching event in the coastal waters of West Hawai`i in 2015, P. meandrina exhibited high post-bleaching mortality with approximately 96% of colonies exhibiting partial post-bleaching tissue loss (greater than 5%) and 78% of colonies exhibiting total post-bleaching mortality (CBD 2018). Other bleaching events in the Hawaiian Islands resulted in 1 to 10% mortality for this species (CBD 2018).

Populations in the Action Area.
Broad Ocean Area: Adults do not occur in the BOA. Gametes and larvae may occur at very low densities in the BOA. See general description of coral occurrence in the BOA in Section 4.5.

Vicinity of Illeginni Islet: *Pocillopora meandrina* has been observed at all 11 of the surveyed Kwajalein Atoll islets since 2010 as well as in the Mid-Atoll Corridor. Overall, *P. meandrina* has been observed at 96% (120 of 125) survey sites in Kwajalein Atoll. This species was observed at 100% (5 of 5) of sites at Illeginni Islet since 2010 (Table 4-7) including in Illeginni harbor.

4.5.20 *Turbinaria mesenterina*

Species Description. *Turbinaria mesenterina* is listed as vulnerable by the IUCN (IUCN 2015). This species was proposed for ESA listing but was subsequently removed from the proposal after NMFS determined that listing it was unwarranted (77 FR 73220 [December 7, 2012]). However, it is currently protected under the UES (USASMDC/ARSTRAT 2018 Section 3-4.5.1). This species in the family Dendrophylliidae is a gray-green or gray-brown coral (Brainard et al. 2011). *Turbinaria mesenterina* colonies form large "lettuce-like" assemblages of variable plates depending on wave motion and light conditions (Brainard et al 2011). Colonies of *T. mesenterina* are generally less than one meter in diameter but can be much larger on fringing reefs (Sakashita and Wolf 2009).

Distribution. *Turbinaria mesenterina* has a broad distribution from eastern Africa to the central Pacific north to Japan and south to southern Africa and the Great Barrier Reef (Brainard et al. 2011). This range includes the US-affiliated waters of American Samoa, Micronesia, the Marshall Islands, the Northern Mariana Islands and Palau (Sakashita and Wolf 2009). This species is found in shallow waters at depths of up to 20 m (66 ft; IUCN Species Account).

Threats. *Turbinaria mesenterina* is susceptible to bleaching, disease, and harvest for the aquarium trade (IUCN Species Account). This species is also threatened by extensive habitat reduction; however, current population trends are unknown (Sakashita and Wolf 2009). Due to these and other general coral threats listed above, this species has an estimated habitat degradation of 36% over 30 years (IUCN Species Account).

Populations in the Action Area.
Broad Ocean Area: Adults do not occur in the BOA. Gametes and larvae may occur at very low densities in the BOA. See general description of coral occurrence in the BOA in Section 4.5.

Vicinity of Illeginni Islet: *Turbinaria mesenterina* has been observed at 5 of the 11 surveyed Kwajalein Atoll islets since 2010 (Table 4-7). In addition to Illeginni, it has been observed during inventories at Roi Namur, Gagan, Omelek, and Legan islets as well as on reefs in the Mid-Atoll Corridor. Overall, *T. mesenterina* has been observed at 4% (5 of 125) survey sites in Kwajalein Atoll. At Illeginni Islet, this species was only observed in Illeginni harbor (20% of Illeginni sites) since 2010 and is not known or expected to occur in reef habitat on the western end of Illeginni Islet.

4.5.21 *Turbinaria reniformis*

Species Description. *Turbinaria reniformis* is listed as vulnerable by the IUCN (IUCN 2015). This species was proposed for ESA listing but was subsequently removed from the proposal after NMFS determined that listing it was unwarranted; however, it is currently protected under the UES (USASMDC/ARSTRAT 2018 Section 3-4.5.1). This species in the family Dendrophylliidae is a yellow-green coral with contrasting colored margins (Sakashita and Wolf 2009). *Turbinaria reniformis* colonies form large stands on fringing reefs where water is turbid and unifacial laminae sometimes form horizontal tiers (Sakashita and Wolf 2009).

Distribution. *Turbinaria reniformis* is found throughout the Red Sea and Gulf of Aden, the Southwest, Northwest, and Central Indian Ocean, the Arabian/Iranian Gulf, the Central Indo-Pacific, Australia, Southern Japan and the South China Sea, the Oceanic West Pacific, and the Central Pacific (IUCN Species Account). This range includes the US-affiliated waters of American Samoa, Micronesia, the Marshall Islands, the Northern Mariana Islands and Palau (Sakashita and Wolf 2009). This species is found at depths of 2 to 15 m (7 to 49 ft; IUCN Species Account).

Threats. *Turbinaria reniformis* is susceptible to bleaching and disease due to its restricted depth range (IUCN Species Account). This species is also threatened by extensive habitat reduction; however, current population trends are unknown (Sakashita and Wolf 2009). Due to these and other general coral threats listed above, this species has an estimated habitat degradation of 36% over 30 years (IUCN Species Account).

Populations in the Action Area.
Broad Ocean Area: Adults do not occur in the BOA. Gametes and larvae may occur at very low densities in the BOA. See general description of coral occurrence in the BOA in Section 4.5.

Vicinity of Illeginni Islet: *Turbinaria reniformis* has been observed at all 11 of the surveyed Kwajalein Atoll islets since 2010 as well as on reefs in the Mid-Atoll Corridor (Table 4-7). Overall, *T. reniformis* has been observed at 30% (37 of 125) survey sites in Kwajalein Atoll. This species was observed at 80% (4 of 5) of sites at Illeginni Islet since 2010 (Table 4-7).

4.5.22 *Turbinaria stellulata*

Species Description. *Turbinaria stellulata* is listed as vulnerable by the IUCN (IUCN 2015). This species was proposed for ESA listing but was subsequently removed from the proposal after NMFS determined that listing it was unwarranted; however, it is currently protected under the UES (USASMDC/ARSTRAT 2018 Section 3-4.5.1). This species in the family Dendrophylliidae is most frequently a brown or green coral but has a wide range of colors (IUCN Species Account). *Turbinaria stellulata* forms colonies less than 50 cm (20 in) in diameter that are primarily encrusting and sometimes dome-shaped (Sakashita and Wolf 2009).

Distribution. *Turbinaria stellulata* is found throughout the Indo-West Pacific including the Red Sea and Gulf of Aden, the Southwest and Central Indian Ocean, the Central Indo-Pacific, Australia, Southern Japan and the South China Sea, and the Oceanic West Pacific (IUCN Species Account). This range includes the US-affiliated waters of American Samoa, Micronesia, the Marshall Islands, the Northern Mariana Islands and Palau (Sakashita and Wolf 2009). This species is found in waters that are not turbid at depths of 2 to 15 m (7 to 49 ft; IUCN Species Account).

Threats. *Turbinaria stellulata* is susceptible to bleaching and disease due to its restricted depth range (IUCN Species Account). This species is also threatened by extensive habitat reduction; however, current population trends are unknown (Sakashita and Wolf 2009). Due to these and other general coral threats listed above, this species has an estimated habitat degradation of 36% over 30 years (IUCN Species Account).

Populations in the Action Area.
Broad Ocean Area: Adults do not occur in the BOA. Gametes and larvae may occur at very low densities in the BOA. See general description of coral occurrence in the BOA in Section 4.5.

Vicinity of Illeginni Islet: *Turbinaria stellulata* has been observed at 6 of the 11 Kwajalein Atoll islets since 2010 (Table 4-7). In addition to Illeginni, it has been observed during inventories at Roi Namur, Legan, Gagan, Gellinam, and Ennugarett islets as well as on reefs in the Mid-Atoll Corridor. Overall, *T. stellulata* has been observed at 16% (20 of 125) survey sites in Kwajalein Atoll. This species was observed at 60% (3 of 5) of sites at Illeginni Islet since 2010 (Table 4-7).

4.6 Mollusks (Phylum Mollusca)

There are five mollusk species that require consultation in the Action Area (Table 4-1 and Table 4-8). The three giant clam species (*Hippopus hippopus, Tridacna gigas,* and *T. squamosa*) are currently ESA candidate species which are protected under the UES. The commercial top shell snail (*Tectus niloticus*) is regulated by Marshall Islands Revised Code 1990, Chapter 3. The black-lipped pearl oyster (*Pinctada margaritifera*) is regulated by Marshall Islands Revised Code 1990, Chapter 1, § 5.

There is no designated critical habitat for mollusks at Kwajalein Atoll.

Summary of Mollusks in the BOA. Adult shallow-water reef-associated mollusks that require consultation do not occur in the BOA or deep ocean waters of the Action Area because their required shallow habitat is absent. At various times of the year the gametes (eggs and sperm) and larvae of reef-associated invertebrates may occur in the BOA or deep ocean waters. With regard to the consultation species addressed in the BA, the most information about reproduction is known for the giant clams. Giant clams are synchronous spawners where release of sperm is triggered by the presence of a spawner with ripe eggs (Munro 1993). Due to the limited time frame of gamete viability (viable up to 8 hours in *T. squamosa* but fertilization success decreased within hours of spawning [Neo et al. 2015]), viable gametes are not likely to be found far from adult clams. Giant clam larvae are considered the dispersal phase where ambient currents and larval swimming speed influence long-distance dispersal (Neo et al. 2015). This long-distance dispersal is limited by the time period during which larvae are able to survive before settlement/recruitment. For most giant clam species, the period from spawning to settlement is approximately 14 days (Ellis 1997, Neo et al. 2015). Due to the short time between fertilization and settlement in giant clams and their time-limited dispersal capability, the abundance of giant clam larvae (especially viable larvae) is likely very low in the open ocean.

The densities of mollusk larvae are difficult to predict, but studies of coral larvae during peak spawning report 0.1 to 1 planktonic larvae per m^3 (per 35.31 ft^3) in waters 5 km (2.7 nm) away from the reef, and 1.6 per m^3 (0.05 per ft^3; brooding species) to 16 per m^3 (0.45 per ft^3; spawning species) in waters directly over the reef during reproduction (Hodgson 1985). Because of the relatively large distances between reefs and the BOA and the larval characteristics of mollusks addressed in this BA, overall larval density in the BOA is likely to be much lower. It is extremely unlikely that shallow-water, reef-associated invertebrate larvae would occur in spent motor drop zones because they are so far up current from their sources. Larval density in the deep ocean waters near USAKA is likely to be near the lower end of its range except during peak spawning when density may be higher.

Summary of Mollusks in the Vicinity of Illeginni Islet. All five of the consultation mollusk species have been observed in the vicinity of Illeginni islet (Table 4-8). Adults of these species have been observed on biennial inventories of the area, and the offshore waters also may support planktonic larvae of mollusks as discussed above. Species specific distribution of adults near Illeginni is discussed below.

Table 4-8
Number of Survey Sites (2010 to present) with Observed Mollusk Consultation Species Occurrences at USAKA Islets (RN = Roi-Namur, ET = Ennugarett, GA = Gagan, GL = Gellinam, OM = Omelek, EK = Eniwetak, MK = Meek, IL = Illeginni, LG = Legan, EN = Ennylabegan, KI = Kwajalein) and Mid-Atoll Corridor (MAC).[1]

Family Scientific Name	RN	ET	GA	GL	OM	EK	MK	IL	LG	EN	KI	MAC	Total	# of Islets
Cardiidae														
Hippopus hippopus	7	3	3	4	4	1	1	**2**	5	1	7	9	47	11
Tridacna gigas	1	1	2	2	1	2	2	**2**	2	1	1	11	28	11
T. squamosa	2	2	-	4	4	4	3	**3**	4	2	-	24	52	9
Pteriidae														
Pinctada margaritifera	2	2	1	-	-	1	2	**1**	1	-	6	-	16	8
Tegulidae														
Tectus niloticus[2]	8	6	5	4	4	2	3	**5**	7	5	18	12	79	11
Total No. Sites Surveyed	**13**	**8**	**5**	**8**	**7**	**5**	**8**	**5**	**7**	**5**	**19**	**35**	**125**	**11**

[1]Sources: USFWS and NMFS 2012, NMFS and USFWS 2013a, NMFS and USFWS 2017, NMFS and USFWS 2018
[2]Within RMI legislation *Tectus niloticus* is inclusive of *Trochus maximus, Trochus niloticus, and Tectus maximus*. This taxon is currently most commonly synonymized under the name *Tectus niloticus*.

4.6.1 *Hippopus hippopus*

Species Description. In August 2016, NMFS was petitioned to list *Hippopus hippopus* under the ESA along with nine other giant clam species (Meadows 2016). In its 90-day finding, NMFS found that listing may be warranted for seven species and initiated a status review for these species including *Hippopus hippopus* (82 FR 28946 [June 26, 2017]). *Hippopus hippopus* are giant clams in the family Cardiidae. These filter feeding bivalves consume plankton; however, in many giant clams, much of their nutrition is obtained from their photosynthetic zooxanthellae symbionts (Klumpp and Lucas 1994). These mollusks are hermaphrodite broadcast spawners, releasing gametes into the water on a seasonal basis at least in the northern and southern limits of their range (Meadows 2016). *Hippopus hippopus* is known to spawn in the austral summer months (December to March) on the Great Barrier Reef but has been known to spawn in June near Palau (Meadows 2016). Fertilized eggs hatch into trochophore larvae which, within a few days, develop into bivalve veligers that feed on plankton (Ellis 1997). Eight to 14 days post fertilization, these veligers metamorphose into juvenile clams that settle on the substrate and acquire mutualistic zooxanthellae (Ellis 1997). The photosynthetic zooxanthellae reside in the mantle of the giant clams where they contribute to clam growth (Mies et al. 2012, Meadows 2016).

Distribution. *Hippopus hippopus* is widely distributed in shallow reef habitats throughout the tropical Indo-Pacific from Burma to the Marshall Islands and from the northern Philippines to New Caledonia (Munro 1993). This species is known to occur in the Marshall Islands, Micronesia, Palau, the Solomon Islands, and Vanuatu but is possibly extirpated from American Samoa, Fiji, Guam, and the Northern Mariana Islands (IUCN Species Account). *Hippopus hippopus* is found in a wide range of habitats including lagoon or fringing reefs, sandy lagoon floors, or exposed intertidal habitats (Munro 1993). It is typically found at depths less than 20 m (66 ft; Meadows 2016).

Giant clams are synchronous spawners where release of sperm is triggered by the presence of a spawner with ripe eggs (Munro 1993). Due to the limited time frame of gamete viability (viable up to 8 hours in *T. squamosa* but fertilization success decreased within hours of spawning [Neo et al. 2015]), viable gametes are not likely to be found far from adult clams. Giant clam larvae are considered the dispersal phase where ambient currents and larval swimming speed influence long-distance dispersal (Neo et al. 2015). This long-distance dispersal is limited by the time period during which larvae are able to survive before settlement/recruitment. For most giant clam species, the period from spawning to settlement is approximately 14 days (Ellis 1997, Neo et al. 2015). Due to the short time between fertilization and settlement in giant clams and their time-limited dispersal capability, the abundance of giant clam larvae (especially viable larvae) is likely very low in the open ocean.

Threats. *Hippopus hippopus* are subject to the same threats as other giant clam species. The major threats for this species include habitat degradation in the form of sedimentation and pollution; harvesting for subsistence, commercial fisheries, the aquarium trade, and the curio trade; and threats from global climate change including bleaching of their symbiotic zooxanthellae and shell degradation from ocean acidification (Meadows 2016).

Populations in the Action Area.
Broad Ocean Area: Adults do not occur in the BOA. Gametes and larvae may occur at very low densities in the BOA. See general description of mollusk occurrence in the BOA in Section 4.6.

Vicinity of Illeginni Islet: *Hippopus hippopus* was observed at all 11 of the surveyed Kwajalein Atoll islets since 2010 as well as at survey sites in the Mid-Atoll Corridor (Table 4-8). Since 2010, *Hippopus hippopus* individuals have been observed at 47 of 125 survey sites (38%) throughout Kwajalein Atoll. This species was recorded at 40% of sites (2 of 5) at Illeginni Islet, during biennial inventories (Table 4-8); on lagoon-side reef crest and slope habitat as well as in Illeginni harbor.

4.6.2 *Pinctada margaritifera*

Species Description. *Pinctada margaritifera* are filter feeders, preying on plankton, bacteria, and particulate organic matter. This species is protected by RMI statute (RMI Marine Resources Act) and under the UES. These mollusks have protandrous hermaphroditic adults that first develop as male and then as females. Eggs and sperm are broadcast into the water where fertilization takes place. These oysters typically spawn bimonthly (Nair 2004) throughout the year with a peak in the austral summer (Thomas et al. 2014). Female black-lipped pearl oysters may produce 40-50 million eggs (Thomas et al. 2014). First stage larvae form within 24 hours of fertilization. The pelagic larval stage lasts for 15 to 30 days before larvae metamorphose and settle to the bottom (Thomas et al. 2014).

Distribution. The black-lipped pearl oyster is found on reef habitats throughout the tropical Indo-Pacific. The location of this species may depend on the locality and local ecosystem conditions. In Hawai`i, *P. margaritifera* was typically found shallower than 8 m (25 ft; Keenan et al. 2006) while deep water stocks at Takapoto Atoll, French Polynesia, exhibited peak abundance between 20 and 40 m (65-130 ft) depth (Zanini and Salvat 2000). Although *Pinctada margaritifera* are occasionally found in the low intertidal zone and can tolerate brief aerial exposure, they are generally found at subtidal depths. The pelagic larval stage of black-lipped pearl oysters is the free-swimming stage (veliger) that enables dispersal and genetic connectivity among populations (Thomas et al. 2014). Dispersal on smaller spatial scales of tens of kilometers is much more common than long distance dispersal (Cowen and Sponaugle 2009; Mumby and Steneck 2008). Altogether this information suggests that veligers may be found in the open ocean but would constitute a small fraction of the total pool of veligers.

Threats. *Pinctada margaritifera* are subject to predation by specialist invertebrates and vertebrates, particularly octopus, sea stars, and some fish. The black-lipped pearl oyster is intensively fished for pearls and nacre (mother of pearl). Wild populations are dramatically reduced from historical baselines.

For example, between 1928 and 1930 at Pearl and Hermes Atolls (in the Northwest Hawaiian Islands), at least 150,000 black-lipped pearl oysters were harvested for pearls and nacre, primarily for making buttons. The same locations in 2003 had approximately 1,000 of these oysters (Keenan et al. 2006). The pearl industry throughout the Pacific now relies heavily on cultivated oyster farms, but wild harvest continues, and population recoveries have not been reported.

Species-specific fisheries are the only known species-specific threats to pearl oysters. Fishing pressure has caused many stocks to collapse, and most are greatly reduced from their historical baselines (Munro 1994; Tardy et al. 2008). However, populations of some marine mollusks increase rapidly when fishing bans are well enforced (Dumas et al. 2010). General threats include habitat degradation and land-based anthropogenic pollution, which interferes with reproduction.

Populations in the Action Area.
Broad Ocean Area: Adults do not occur in the BOA. Gametes and larvae may occur at very low densities in the BOA. See general description of mollusk occurrence in the BOA in Section 4.6.

Vicinity of Illeginni Islet: *Pinctada margaritifera* was observed at 8 of the 11 surveyed Kwajalein Atoll islets since 2010 (Table 4-8). In addition to Illeginni, it was found at Kwajalein, Roi Namur, Omelek, Gagan, Meck, Eniwetak, and Ennugarett islets. Since 2010, *Pinctada margaritifera* individuals have been observed at 16 of 125 survey sites (13%) throughout Kwajalein Atoll. At Illeginni Islet, this species has been recorded at 20% (1 of 5) of survey sites on the lagoon-side reef slope (Table 4-8). Since *P. margaritifera* is a reef slope dwelling species, it occurs below the areas that have the potential to be affected by the Action in the vicinity of Illeginni islet.

4.6.3 *Tectus (Trochus) niloticus*

Species Description. This species is protected under RMI statute (RMI Marine Resources (Trochus) Act of 1983) and under the UES. Within RMI legislation *Tectus niloticus*, a consultation species, is inclusive of *Trochus maximus*, *Trochus niloticus*, and *Tectus maximus*. Most biological authorities currently synonymize all of these under the name *Tectus niloticus* (the commercial top shell snail), based on genetic information available since 2008 (see Bouchet 2012). Generally cited as *Trochus niloticus* in material older than 2008, *Tectus niloticus* is typically found shallower than 12 m (40 ft), and the typical adult shell is 10 to 12 cm (4 to 5 in) long. Although some species are occasionally found in the low intertidal zone and can tolerate brief aerial exposure, all members of Tegulidae are generally found at subtidal depths (Dumas et al. 2010; Tardy et al. 2008). These herbivorous snails, like conchs, are oviparous with females releasing more than 1 million eggs (SPC 2016). Pelagic veligers of *Tectus niloticus* are free-swimming for at least 3 to 5 days before metamorphosis and subsequent settlement on substrate (SPC 2016). All members of this snail family are herbivores and occasionally detritivores.

Distribution. *Tectus niloticus* occupies intertidal and shallow subtidal zones on the seaward margin of reefs at depths up to 27 m (89 ft). *Tectus niloticus* occurs throughout the Indo-Pacific and due to its commercial value, it has been translocated or introduced to many Indo-Pacific regions. Reproduction of mollusks often includes a free-swimming stage (veliger) enabling dispersal over great distances, and genetic similarity across most mollusk species' ranges indicates that long-distance dispersal occurs with regularity. Dispersal on smaller spatial scales of tens of kilometers is much more common (Cowen and Sponaugle 2009; Mumby and Steneck 2008). Altogether this suggests that veligers will be found in the open ocean, but this is a small fraction of the total pool of veligers.

Threats. All members of the family Tegulidae are subject to predation by specialist invertebrates and vertebrates, but principally by octopus and triggerfish (Family Balistidae). The rate of predation decreases as the animals grow, and it is thought that the largest individuals are not preyed on because there are no predators large enough to take them (McClanahan 1990). All members of the family Tegulidae, including *Tectus niloticus*, are also subject to fishing pressure for food and for the aquarium and curio trades (Tardy et al. 2008). This has led to widespread declines of top shell snails near human populations and to regional extinctions on small reef habitats next to large human populations (e.g., all top shell snails on Guam and the Northern Mariana Islands; Munro 1994; IUCN Species Account).

Species-specific fisheries are the only known species-specific threats to top shell snails. Fishing pressure has caused many stocks to collapse, and most are greatly reduced from their historical baselines (Munro 1994; Tardy et al. 2008). However, populations of Tegulidae and other marine mollusks increase rapidly when fishing bans are well enforced (Dumas et al. 2010). General threats include habitat degradation and land-based anthropogenic pollution, which interferes with reproduction.

Populations in the Action Area.
Broad Ocean Area: Adults do not occur in the BOA. Gametes and larvae may occur at very low densities in the BOA. See general description of mollusk occurrence in the BOA in Section 4.6.

Vicinity of Illeginni Islet: *Tectus niloticus* was observed at all 11 of the Kwajalein Atoll islets as well as on reefs in the Mid-Atoll Corridor (Table 4-8). *Tectus niloticus* is fairly widespread and common. Since 2008, T. *niloticus* individuals have been observed at 59 of 103 survey sites throughout Kwajalein Atoll, including all four survey sites at Illeginni islet, during biennial inventories (Table 4-8).

4.6.4 *Tridacna gigas*

Species Description. In August 2016, NMFS was petitioned to list *Tridacna gigas* under the ESA along with nine other giant clam species (Meadows 2016). In its 90-day finding, NMFS found that listing may be warranted for seven species and initiated a status review for these species including *Tridacna gigas* (82 FR 28946 [June 26, 2017]). *Tridacna gigas* are in the family Cardiidae and are the largest species, reaching widths of 120 cm (47 in) and 200 kg (440 lb; Meadows 2016). These filter feeding bivalves consume plankton but also obtain a portion of their nutrition from their photosynthetic zooxanthellae symbionts (Klumpp and Lucas 1994). In contrast to many giant clams, T. gigas is a very efficient filter feeder and gets a large portion of the carbon it needs for respiration and growth (34 to 65%) from filter-feeding (Klumpp and Lucas 1994). These mollusks are hermaphrodite broadcast spawners, releasing gametes into the water on a seasonal basis at least in the northern and southern limits of their range (Meadows 2016). The optimal reproductive season for *Tridacna gigas* may be from October to February and spawning has been known to coincide with incoming tides and moon phases (Meadows 2016). Fertilized eggs hatch into trochophore larvae which, within a few days, develop into bivalve veligers that feed on plankton (Ellis 1997). Eight to 14 days post fertilization, these veligers metamorphose into juvenile clams that settle on the substrate and acquire mutualistic zooxanthellae (Ellis 1997). The photosynthetic zooxanthellae reside in the mantle of the giant clams where they contribute to clam growth (Mies et al. 2012, Meadows 2016).

Distribution. *Tridacna gigas* was historically widely distributed in shallow reef habitats throughout the tropical Indo-Pacific (Munro 1993) from Burma to the Marshall Islands and from Japan to New Caledonia (Meadows 2016). This species is known to occur in the Marshall Islands, Micronesia, Palau, and the Solomon Islands but is possibly extirpated from Fiji, Guam, Vanuatu, New Caledonia, and the Northern Mariana Islands (Munro 1993, IUCN Species Account). *Tridacna gigas* is found in a wide range of habitats including high- and low-islands and lagoon or fringing reefs (Munro 1993). It is typically found at depths less than 20 m (66 ft; Meadows 2016).

Giant clams are synchronous spawners where release of sperm is triggered by the presence of a spawner with ripe eggs (Munro 1993). Due to the limited time frame of gamete viability (viable up to 8 hours in *T. squamosa* but fertilization success decreased within hours of spawning [Neo et al. 2015]), viable gametes are not likely to be found far from adult clams. Giant clam larvae are considered the dispersal phase where ambient currents and larval swimming speed influence long-distance dispersal (Neo et al. 2015). This long-distance dispersal is limited by the time period during which larvae are able to survive before settlement/recruitment. For most giant clam species, the period from spawning to settlement is approximately 14 days (Ellis 1997, Neo et al. 2015). Due to the short time between fertilization and settlement in giant clams and their time-limited dispersal capability, the abundance of giant clam larvae (especially viable larvae) is likely very low in the open ocean.

Threats. *Tridacna gigas* are subject to the same threats as other giant clam species. The major threats for this species include habitat degradation in the form of sedimentation and pollution; harvesting for subsistence, commercial fisheries, the aquarium trade, and the curio trade; and threats from global climate change including bleaching of their symbiotic zooxanthellae and shell degradation from ocean acidification (Meadows 2016). There is some evidence that T. gigas may also be threatened by protozoan and gastropod parasites which may be lethal for clams or reduce their growth rate (Meadows 2016).

Populations in the Action Area.
Broad Ocean Area: Adults do not occur in the BOA. Gametes and larvae may occur at very low densities in the BOA. See general description of mollusk occurrence in the BOA in Section 4.6.

Vicinity of Illeginni Islet: *Tridacna gigas* was observed at all 11 of the surveyed Kwajalein Atoll islets since 2010 as well as on reefs in the Mid-Atoll Corridor (Table 4-8). While found at all islets, *Tridacna gigas* had a relatively low distribution at these islets; being found at only 22% of surveyed sites (28 of 125) throughout Kwajalein Atoll. This species was found at 40% of sites (2 of 5) at Illeginni Islet, including at a lagoon reef crest site and in Illeginni harbor (Table 4-8).

4.6.5 *Tridacna squamosa*

Species Description. In August 2016, NMFS was petitioned to list *Tridacna squamosa* under the ESA along with nine other giant clam species (Meadows 2016). In its 90-day finding, NMFS found that listing may be warranted for seven species and initiated a status review for these species including *Tridacna squamosa* (82 FR 28946 [June 26, 2017]). *Tridacna squamosa* is a giant clam species in the family Cardiidae that reaches more than 35 cm (14 in; Munro 1993). These filter feeding bivalves consume plankton; however, in many giant clams, much of their nutrition is obtained from their photosynthetic zooxanthellae symbionts (Klumpp and Lucas 1994). These mollusks are hermaphrodite broadcast spawners, releasing gametes into the water (Meadows 2016). Spawning phenology for this species is unknown for most areas. Fertilized eggs hatch into trochophore larvae which, within a few days, develop into bivalve veligers that feed on plankton (Ellis 1997). These veligers then metamorphose into juvenile clams that settle on the substrate and acquire mutualistic zooxanthellae (Ellis 1997). In T. squamosa, 80% of larvae had settled by 13-days post fertilization and no swimming was observed in larvae greater than 14 days old (Neo et al. 2015). The photosynthetic zooxanthellae reside in the mantle of the giant clams where they contribute to clam growth (Mies et al. 2012, Meadows 2016).

Distribution. *Tridacna squamosa* has a wide but fairly limited distribution. This species is found in shallow reef habitats from west Africa to French Polynesia and the East China Sea to the Great Barrier Reef (Meadows 2016). This species is known to occur in the Marshall Islands, Micronesia, Palau, Vanuatu, and the Solomon Islands but is possibly extirpated from Japan and the Northern Mariana Islands (IUCN Species Account). *Tridacna squamosa* is found in sheltered lagoon environments adjacent to high islands and larvae may prefer substrate with crustose coralline algae (Meadows 2016). This species is typically found at depths less than 20 m (66 ft; Meadows 2016).

Giant clams are synchronous spawners where release of sperm is triggered by the presence of a spawner with ripe eggs (Munro 1993). Due to the limited time frame of gamete viability in *T. squamosa* (viable up to 8 hours but fertilization success decreases within hours of spawning [Neo et al. 2015]), viable gametes are not likely to be found far from adult clams. Giant clam larvae are considered the dispersal phase where ambient currents and larval swimming speed influence long-distance dispersal (Neo et al. 2015). This long-distance dispersal is limited by the time period during which larvae are able to survive before settlement/recruitment. For most giant clam species, the period from spawning to settlement is approximately 14 days (Ellis 1997, Neo et al. 2015). Due to the short time between fertilization and settlement in giant clams and their time-limited dispersal capability, the abundance of giant clam larvae (especially viable larvae) is likely very low in the open ocean.

Threats. *Tridacna squamosa* are subject to the same threats as other giant clam species. The major threats for this species include habitat degradation in the form of sedimentation and pollution; harvesting for subsistence, commercial fisheries, the aquarium trade, and the curio trade; and threats from global climate change including bleaching of their symbiotic zooxanthellae and shell degradation from ocean acidification (Meadows 2016). High ocean temperature bleaching has been recorded in *T. squamosa* in Singapore and increased respiration and decreased production in response to increase temperature has also been observed for this species (Meadows 2016).

Populations in the Action Area.
Broad Ocean Area: Adults do not occur in the BOA. Gametes and larvae may occur at very low densities in the BOA. See general description of mollusk occurrence in the BOA in Section 4.6.

Vicinity of Illeginni Islet: *Tridacna squamosa* was observed at 9 of the 11 surveyed Kwajalein Atoll islets since 2010 as well as on reefs in the Mid-Atoll Corridor (Table 4-8). In addition to Illeginni Islet, *Tridacna squamosa* was observed at Roi-Namur, Ennugarett, Gellinam, Omelek, Meck, Legan, and Ennylabegan islets. This species was recorded at 42% (52 of 125) of sites throughout Kwajalein Atoll. *Tridacna squamosa* was found at 60% (3 of 5) of sites at Illeginni Islet, including in lagoon reef crest and both lagoon and ocean slope habitats as well as in Illeginni harbor (Table 4-8).

5.0 EFFECTS OF THE ACTION

This section examines the ways in which the FE-2 flight may directly and indirectly affect cetacean, phocid, seabird, sea turtle, fish, coral and mollusk consultation species in the Action Area. The potential direct and indirect effects of the FE-2 flight on the species described in Section 4.0 and their habitats in each of the three portions of the Action Area are analyzed. The potential effects of five general types of FE-2 project-related stressors are discussed in the subsections below: exposure to elevated sound levels, direct contact and/or shock waves, vessel strike, exposure to hazardous chemicals, and disturbance from human activities. The potential of each stressor to affect consultation species is analyzed for each of the two portions of the Action Area: the BOA and at or in the vicinity of Illeginni Islet. Effect determinations are summarized in Section 7.0 “Conclusions” and in Table 7-1.

While the potential for adverse effects from these stressors will diminish with increasing distance from their sources, they will also decrease with water depth. For example, the magnitude of effects associated with payload impact is generally inversely proportional to depth (i.e., impacts in deeper water expose the biota to less of each effect). The effects from an object as it falls through the water column is possible, but it is not very likely because objects generally sink through the water relatively slowly and can be avoided by most cetaceans and sea turtles. The velocity of fragments from impact will decrease substantially in the first 5 m (15 ft) of water, and seismic effects decrease to nearly zero as water depth exceeds 0.3 m (1 ft; USAFGSC and USASMDC/ARSTRAT 2015). Payload impact would not form craters in depths greater than approximately 3 to 5 m (10 to 15 ft; USAFGSC and USASMDC/ ARSTRAT 2015). Dilution and dispersion of chemicals would also increase with water depth. Because effects for FE-2 related stressors are greatest at or near the surface, the discussion of the effects of stressors will generally focus on the potential for effects at or near the surface of the water.

Following the analysis of effects for each group of species, an effect determination is provided, as defined under the ESA. The effects determinations are either 1) beneficial effect; 2) no effect; 3) may affect but not likely to adversely affect; or 4) may affect and likely to adversely affect. The UES has only two results, either may affect or no adverse effect. In this BA, only ESA terminology is used for effects determinations. The effect determination depends on the likelihood of proposed FE-2 flight test to result in harm or harassment of a species requiring consultation (individual effects) and the potential of the Action to have population-level effects for these species. An organism’s potential to recover from injury or other effects is a function of intrinsic factors (e.g., existing health and fitness) and extrinsic factors (e.g., environmental extremes, habitat conditions, and food availability).

A brief discussion of stressors for Newell’s shearwaters resulting from launch activities at PMRF is also included in Section 5.2. While the effects of STARS launch activities at PMRF have been previously analyzed in the *HRC EIS/OEIS* (US Navy 2008). Newell’s shearwater is a highly sensitive species on Kauai and PMRF is currently in consultation with USFWS for this species for base wide activities at PMRF. Therefore, we include a description of the stressors for this species at PMRF, an analysis of the effects of these stressors and an effect determination for this species.

Harm and harassment are defined under the MMPA and the ESA. All marine mammals are protected under the MMPA. As defined by the MMPA, level A harassment of cetaceans is any act which has the potential to injure a marine mammal or marine mammal stock in the wild. Level B harassment is defined as any act which has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including but not limited to migration, breathing, nursing, breeding, feeding, or sheltering. In 2004, the MMPA was amended to include a separate definition of "harassment" for military reediness activities: "(i) any act that injures or has the significant potential to injure a marine mammal or marine mammal stock in the wild; 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" (16 USC 1362(18)(B)).

For all ESA listed species, the ESA defines "harm" as an act which kills or injures wildlife including significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering (16 USC §§ 1531-1544). The ESA defines harassment as an intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to breeding, feeding, or sheltering.

5.1 Stressors

5.1.1 Exposure to Elevated Sound Levels

The Proposed Action has the potential to result in elevated SPLs both in-air and underwater. The primary elements of the Proposed Action that would result in elevated sound pressure levels are: (1) sonic booms, (2) splashdown of spent rocket motors stages and other vehicle components, and (3) impact of the developmental payload. The Proposed Action has sources or elevated sound levels that are very similar to those analyzed in the FE-1 BA (US Navy 2017a); therefore, analyses in this section follow the methodologies of the FE-1 BA.

Sound creates vibrations that travel through air or water. Sound vibrations are characterized by their frequency (generally expressed in Hz) and amplitude or loudness, which is quantified here using the logarithmic dB. In water, SPLs are typically referenced to a baseline of 1 μPa, whereas in-air pressures are typically referenced to 20 μPa. In-air pressure measurements are converted to in-water estimates where necessary. Unless noted, all SPLs in the following analyses are in-water pressures; therefore, all dB levels presented below assume dB re 1 μPa (unless specifically noted). For many organisms it can be useful to distinguish between peak exposure levels (dB_{peak}) and total exposure over time (SEL). For some organisms, effects are compared to thresholds based on the root mean square (RMS) SPL, which is the quadratic mean sound pressure over the duration of the sound.

5.1.1.1 Sources of Elevated Sound Levels

Sonic Booms. The launch vehicle and the developmental payload will fly at velocities sufficient to generate sonic booms from close to launch at PMRF and extending to impact at or near Kwajalein Atoll. Sonic booms create elevated pressure levels both in-air and underwater. The sonic boom generated by the FE-2 test flight has been estimated and is detailed in Appendix A. Numerous assumptions were made for sonic boom calculations (Appendix A) and all assumptions were made to err on the side of conservatism, yielding calculated values larger than what will likely occur during the test flight. Table 5-1 shows sonic boom SPLs at various stages during the trajectory.

The sonic boom will propagate up-range from the launch site and extend downrange along the entire flight path. The FE-2 sonic boom overpressures in the water at the ocean surface were estimated to be near their maximum level (~145 dB) near the launch site and would only be at this level for a short downrange distance and extending out from the flightpath less than 28 km (15 nm). After the sonic boom peaks at 135 dB over the BOA, the average 130 dB footprint extends out from the flight path no more than 55 km (30 nm). The duration of these overpressures is expected to average 270 milliseconds (ms) where SPLs are less than 140 dB (Appendix A), and the overpressure (sound levels) would dissipate with increasing distance and ocean depth.

Table 5-1.
Estimated Sonic Boom Peak Sound Pressure Levels in Water for FE-2 Trajectory.

Reference	Sound Pressure Level (dB re 1 μPa)	Approximate Location
Boost (Maximum)	145	Near launch at KTF
Flight (Maximum)	135	BOA
Flight (Average)	130	BOA
Terminal (Maximum)	175	Near payload impact at Illeginni Islet

At the terminal end of the flight path, the sonic boom generated by the approaching payload is estimated to peak at less than 175 dB near impact. At the point of impact, the sonic boom footprint would narrow to about 46 km (25 nm) at this peak pressure. For payload impact at Illeginni Islet, elevated SPLs due to the sonic boom would be present in the air over land and would also be present in the surrounding waters. The duration for sonic boom overpressures produced by the payload are expected to average 75 ms where SPLs are greater than 140 dB and 270 ms where SPLs are less than 140 dB.

For the entire FE-2 flight path, affect areas for sonic booms were calculated at various acoustic intensities (dB re 1 μPa; Appendix A). Approximately 2.4 km^2 (0.9 mi^2) of ocean surface would be exposed to SPLs up to 170 dB, 45 km^2 (17 mi^2) to SPLs up to 160 dB, and 474 km^2 (183 mi^2) to SPLs up to 150 dB. Assuming an "N-Wave" sonic boom, a wide range of frequencies at various pressure levels is expected (see Appendix A). As stated above, the model assumptions for estimating sonic boom overpressures likely resulted in conservatively high estimates of sonic boom pressures and, therefore, conservative estimates of affect area.

In-air at the ocean surface, sonic boom SPLs would not exceed 119 dB re 20 μPa in the BOA and would be no greater than 149 dB re 20 μPa near payload impact at Illeginni Islet.

Splashdown of Spent Rocket Motors and Other Vehicle Components. Elevated SPLs would occur in the ocean as spent rocket motors and payload components impact the ocean's surface. Three spent rocket motor drop zones are identified in the BOA of the Action Area between 65 and 2,800 km (35 and 1,500 nm) from the launch pad (Figure 3-2). The nose fairing covering the payload is expected to fall into the second spent motor drop zone.

Estimates of splashdown forces and associated SPLs for FE-2 spent motors and the nose fairing have been estimated based on the size, shape, weight, trajectory, and impact velocity of the components (Appendix A and Table 5-2). The calculations for these estimates were made with numerous assumptions (see Appendix A), and all assumptions were made to err on the side of conservatism, yielding values larger than what would actually occur. All estimates are presented as in-water (at the surface) SPLs in dB re 1 μPa. The frequency of stage impacts is estimated to range from 100 Hz to 4 kHz (see Appendix A for stage impact power spectrum).

Table 5-2.
Estimated Stage Impact Contact Areas and Peak Sound Pressure Levels for FE-2 Vehicle Components.

Stage	Contact Area m^2 (ft^2)	Peak Sound Pressure Level (dB re 1 μPa)
Stage 1 Spent Motor	27.73 (81.12)	218
Stage 2 Spent Motor	10.17 (33.38)	205
Nose Fairing	16.81 (55.14)	196
Stage 3 Spent Motor	5.94 (19.5)	201

Sources: Appendix A

The effects of elevated sound levels due to splashdown of spent vehicle components are only expected to occur in the BOA of the Action Area. Using a spherical spreading model:

$$Range\ to\ Threshold\ (m) = 10\text{^}\left(\frac{dB_{source} - dB_{threshold}}{x}\right)$$

where x is the spreading coefficient (x=20 for deep ocean waters and x=15 for shallow waters), and SPLs are in dB_{peak} re 1 μPa. The range to threshold was calculated for the biologically relevant thresholds for species addressed in this BA (Section 5.1.1.2) and an affect area was calculated for each relevant threshold using:

$$Affect\ Area\ (m^2) = \pi(Range\ to\ Threshold)^2.$$

While there are no calculated estimates of duration for elevated SPLs associated with vehicle component splashdown, these elevated SPLs are not expected to last more than a few seconds.

Impact of the Developmental Payload. Impact of the developmental payload at the terminal end of the flight will also result in elevated in-air and/or underwater sound levels. Estimates for pressure from impact of vehicles using a similar amount of high explosive as those in the payload resulted in SPLs in-air of 140 dB re 20 μPa at 18 m (59 ft). These levels will be used as a bounding case for the current Proposed Action. Using the spherical spreading model above, the dB source level is estimated to be 165 dB in-air and an estimated 191 dB in-water.

For payload impact at Illeginni Islet, in-air pressure levels may remain above 140 dB up to 18 m (58 ft) from the impact site. The impact may result in some in-water elevated SPLs in the shallow waters surrounding Illeginni Islet. Using the cylindrical spreading model for shallower waters and an in-water source level of 191 dB, SPLs may be above 160 dB out to 117 m (383 ft) and above 150 dB out to 541 m (1,775 ft).

5.1.1.2 Effect Thresholds for Consultation Species

Noise from sonic booms, splashdown of vehicle components, and payload impact could affect the behavior and hearing sensitivity in marine mammals, birds, sea turtles, and fish in the Action Area. Loud sounds might cause these organisms to quickly react, altering their normal behavior either briefly or more long term or may even cause physical injury. The extent of the effect depends of the frequency and intensity of the sound as well as on the hearing ability of the organism. Consultation species have different hearing abilities and thresholds for effects which will be discussed below. In general, an SPL that is sufficient to cause physical injury to auditory receptors is a sound that exceeds an organism's permanent threshold shift (PTS) level. Depending on the species, higher SPLs may induce other physical injury or, in extreme cases, even death. The extent of physical injury depends on the SPL as well as the anatomy of each species.

A temporary threshold shift (TTS) is when an organism is exposed to sound pressures below the threshold of physical injury but may result in temporary hearing alteration. These sound levels may impede a marine mammal's, bird's, sea turtle's, or fish's ability to hear, even after the exposure has ended, temporarily raising the threshold at which the animal can hear. TTS can temporarily impair an animal's ability to communicate, navigate, forage, and detect predators. The onset of threshold shift in hearing in cetaceans depends on the total exposure to sound energy, a function of SPL and duration of exposure. As a sound gets louder, the duration required to induce threshold shifts gets shorter (NRC 2003).

Another common effect of elevated SPLs is behavioral modification. Most observations of behavioral responses to anthropogenic sounds have been limited to short-term behavioral responses, which include disturbance to feeding, resting, or social interactions (NRC 2003). For marine mammals, behavioral responses may include changes in surfacing, breathing patterns, dive duration, vocalization, and group composition but tend to be highly variable (NRC 2003). In addition to an animal's hearing ability and loudness of the sound, factors such as the contemporaneous behavioral state, age, and sex of the animal as well as the source of the noise or movement of the noise source can all affect how likely an animal is to be disturbed by a noise (NRC 2003). While several studies have recorded changes in marine mammal behavior in responses to noise, these studies do not provide evidence that these behavioral changes are biologically significant for the animals (NRC 2003). It is very possible that these behavioral responses, especially if they result in longer term changes in behavior, may use energy and time that might otherwise have been used for foraging or reproduction (NRC 2003) which might ultimately affect the fitness of the animal. Marine mammals have been observed to cease vocalization in response to noise but some species are also known to change both the frequency and rate of vocalization (NRC 2003), which can have further implications on breeding, feeding, and social interacting. While sounds resulting in one-time acute responses are less likely to result in stress than repeated, long-term exposure (NRC 2003), noise can cause physiological stress response in marine mammals (Erbe et al. 2018). Predicting behavioral response and relating behavioral response to changes in the health of individual marine mammals remains difficult (Erbe et al. 2018).

Interpreting the effects of noise on marine mammals, birds, sea turtles, and fish depends on various parameters, including the SEL and duration, the sound frequency, and the animal's hearing ability. As discussed above, SPLs can be expressed in several ways, including: (1) peak pressure levels expressed in either psi, or dB re 1 μPa, and (2) the average or root-mean-square (RMS) level over the duration of the sound, also expressed in dB re 1 μPa. Acoustic thresholds for some species have also been established with reference to SEL where the sound pressure is squared and integrated over the duration of the signal and summed for multiple events to result in a cumulative SEL (SEL_{cum}). Because the expected underwater noise levels from sonic booms and component impacts represent single pulses that are relatively low in acoustic strength and very short in duration, peak pressure levels were used for analysis purposes. Because the sound durations for stage impacts are unknown and there is only a single event, we use the rule of thumb outlined by the US Navy (2015a) that the numeric value of SEL is equal to the SPL of a one-second sound that has the same total energy as the exposure event (US Navy 2015a). Therefore, if the sound duration is one second, SPL and SEL have the same numeric value (but not the same reference quantities as SEL is dB re 1 μPa^2-s; US Navy 2015a). This assumes that the SPL is held constant. Since the duration of the SPLs is unknown, we use one second as a likely conservative estimate of stage impact effects since any duration changes would change SEL as a function of $10\log_{10}$(duration) and a decrease in duration would lower the estimated SEL dB (US Navy 2015a).

Cetaceans. General hearing abilities and know hearing capabilities for cetaceans and of individual consultation species are discussed in Section 4.1. For assessing TTS and PTS effects on cetaceans in the Action Area, this analysis used the revised acoustic threshold criteria from NMFS "2018 Revisions to: Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing" (NOAA 2018b). The current thresholds depend on the hearing ability of marine mammals where cetaceans are separated into low-frequency, mid-frequency, and high-frequency functional hearing groups (Table 5-3). In these analyses, cetacean groups are referred to by their functional hearing groups where animals in the low-frequency cetacean group have an estimated auditory bandwidth of 7 Hz to 22 kHz, 150 Hz to 160 kHz in the mid-frequency cetacean group, and 200 Hz to 180 kHz in the high-frequency cetacean group (Southall et al. 2007). The revised thresholds use both peak sound pressure levels (SPL_{peak}) and accumulated sound exposure levels (SEL_{cum}; NOAA 2018b). Since elevated SPLs

Table 5-3.
Marine Mammal Functional Hearing Groups for Assessing the Effects of Elevated Sound Pressure Levels.

Functional Hearing Group	Species	
Low-frequency Cetaceans	Minke whale	*Balaenoptera acutorostrata*
	Sei whale	*B. borealis*
	Bryde's whale	*B. edeni*
	Blue whale	*B. musculus*
	Fin whale	*B. physalus*
	Humpback whale	*Megaptera novaeangliae*
Mid-Frequency Cetaceans	Short-beaked common dolphin	*Delphinus delphis*
	Pygmy killer whale	*Feresa attenuata*
	Short-finned pilot whale	*Globicephala macrorhynchus*
	Risso's dolphin	*Grampus griseus*
	Longman's beaked whale	*Indopacetus pacificus*
	Fraser's dolphin	*Lagenodelphis hosei*
	Blainville's beaked whale	*Mesoplodon densirostris*
	Killer whale	*Orcinus orca*
	Melon-headed whale	*Peponocephala electra*
	Sperm whale	*Physeter macrocephalus*
	False killer whale	*Pseudorca crassidens*
	Pantropical spotted dolphin	*Stenella attenuata*
	Striped dolphin	*S. coeruleoalba*
	Spinner dolphin	*S. longirostris*
	Rough-toothed dolphin	*Steno bredanensis*
	Bottlenose dolphin	*Tursiops truncatus*
	Cuvier's beaked whale	*Ziphius cavirostris*
High-frequency Cetaceans	Pygmy sperm whale	*Kogia breviceps*
	Dwarf sperm whale	*K. sima*
Phocids	Hawaiian monk seal	*Neomonachus schauinslandi*

Source: NOAA 2018b, Southall et al. 2007 for the FE-2 flight are very short in duration, we use peak exposure levels to estimate the effects of the pressures on consultation organisms (Table 5-4) as in the FE-1 BA (US Navy 2017a). Because the revised acoustic threshold criteria used by NMFS (NOAA 2018b) include only thresholds for PTS and TTS and no criteria for behavioral effects, we use the "Criteria and Thresholds for US Navy Acoustic and Explosive Effect Analysis" (Finneran and Jenkins 2012). The current US Navy standard for analysis for single explosive events is not to use a behavioral disturbance threshold for marine mammals as any behavioral disturbance from this type of event is likely to be limited to a short-lived startle reaction (Finneran and Jenkins 2012).

Table 5-4.
Acoustic Thresholds for PTS, TTS, and Behavioral Disruption from Single Exposure to Impulsive In-Water Sounds in Marine Mammals. Peak SPL thresholds in dB re 1 µPa.

Functional Hearing Group	PTS threshold ($dB\ SPL_{peak}$)	TTS Threshold ($dB\ SPL_{peak}$)	Behavioral Disruption[1]
Low-frequency Cetaceans	219	213	NA
Mid-frequency Cetaceans	230	224	NA
High-frequency Cetaceans	202	196	NA
Phocids	218	212	NA

Sources: NOAA 2018b

[1] For single explosive events, behavioral disturbance is likely to be limited to a short-lived startle reaction; therefore, the US Navy does not use any unique behavioral disturbance thresholds for marine mammals exposed to single explosive-like events.

Phocids. For phocids, the current thresholds used by NMFS to evaluate the onset of PTS and TTS are ≥ 212 dB and ≥ 218 dB, respectively (NOAA 2018b; Table 5-4). As with other marine mammals, the US Navy does not use any unique behavioral disturbance thresholds for exposure to single explosive events because any behavioral disturbance is likely to be limited to a short-lived startle reaction. These threshold standards were used in FE-1 BA analyses (US Navy 2017a) and are used here for the Proposed FE-2 Action.

Birds. Hearing range and sensitivity has been determined from many land birds; however, seabird hearing remains largely unknown (US Navy 2015a). Studies of terrestrial and marine bird hearing have shown greatest hearing sensitivity for these species between 1 and 4 kHz with minimum detectable frequency around 20 Hz and maximum hearing limit of 15 kHz (US Navy 2015a). While most seabirds found in the ROI feed by diving, skimming, or grasping prey at the water's surface or within 1-2 m (3-6 ft) of the surface, there is little published literature on the hearing abilities of seabirds underwater (US Navy 2015a). A bird's response to noise depends on many factors including life-history characteristics of the species, frequency and amplitude of the noise source, distance from the noise source, presence of visual stimuli, and previous exposure to similar sounds (US Navy 2015a). For these analyses we use auditory effect thresholds for seabirds following the FE-1 BA (US Navy 2017a) as detailed below.

If a seabird were exposed to elevated SPLs in-air or under water, it could suffer auditory fatigue (hearing sensitivity over a portion of hearing range) or behavioral disruption (US Navy 2015a). As with other marine organisms, auditory threshold shifts may be either permanent (PTS) or temporary (TTS). Unlike most other taxa, birds have the ability to regenerate hair cells in the inner ear, which allows them to recover from auditory injury better than other species, usually within several weeks (US Navy 2015a). Some very intense sounds may result in permanent hearing damage in birds. Few studies have examined hearing loss in seabirds; however, the US Navy's current standard of analysis uses a PTS threshold of 110 A-weighted decibels (dBA) re 20 µPa for continuous sounds and 140 dB re 20 µPa for blast noise (US Navy 2015a).

The physiological effects of elevated pressure levels on birds underwater is less well known; elevated pressure levels from detonations have been known to have adverse physiological effects on a variety of vertebrate species (NMFS 2015a). The extent to which a bird may be injured by underwater explosive events depends on the bird's size, the anatomy of the bird, and the location of the bird relative to the source of the event (NMFS 2015a). The USFWS established thresholds for onset of injury to marbled murrelets (which are similar in size [approximately 33 cm or 13 in] to Newell's shearwaters) from underwater explosions in the Northwest Training and Testing BO (NMFS 2015a). The USFWS established an auditory injury threshold for underwater explosions of 212 dB SEL re 1 μPa/sec, a barotrauma threshold of 36 Pa/sec, and a mortality threshold of 138 Pa/sec (NMFS 2015a).

Behavioral responses to elevated SPLs in birds include behaviors such as alert behavior, startle response, avoidance behavior, and increased vocalizations (US Navy 2015a). In some cases, where noises induce behavioral response repeatedly over time, effects to birds may include chronic stress, which may compromise the overall heath and reproductive success (US Navy 2015a). The reported behavioral and physiological response of birds to elevated sounds as in the Proposed Action can fall within the range of normal adaptive responses to stressors such as predation which birds experience on a daily basis (US Navy 2015a). There is also some evidence that certain birds may become habituated to noises after frequent exposure and cease to respond behaviorally (US Navy 2015a). While birds may experience behavioral and physiological responses to sounds, for short duration and unrepeated sounds, birds may return to normal almost immediately after exposure, and no long-term effects are expected. Conservative estimates of sound effects on birds have been presented by the California Department of Transportation (Dooling and Popper 2007). These estimates based on dBA (A-weighted for human hearing) do not provide accurate estimates of the noise level in the frequency range where birds hear and communicate; however, they can provide an overestimate of effects and therefore very conservative (if not realistic) thresholds of effect (Dooling and Popper 2007). A 93 dBA (in-air) threshold for physiological or behavioral disruption from continuous noise sources has been suggested as a very conservative estimate of effects in birds (Dooling and Popper 2007). While no data supported thresholds are known for impulsive sounds and the behavioral effects of this single impulsive even are expected to be limited to short-duration startle reactions, the threshold for continuous noise can be used as a very conservative threshold of effects.

Sea Turtles. For sea turtles, we use the criteria and acoustic threshold standards which have been used by the US Navy for explosive sources (Table 5-5; Finneran and Jenkins 2012) and were used to analyze the effects of the FE-1 test (US Navy 2017a). These criteria and acoustic thresholds for sea turtles are similar to those proposed for marine mammals, and all sea turtles are placed into a single functional hearing group (Finneran and Jenkins 2012). Sea turtles have a functional hearing range of approximately 100 Hz to 1 kHz with and upper frequency limit of 2 kHz (Finneran and Jenkins 2012). Physiological effects of elevated SPLs from explosive sources can include not only auditory effects (PTS and TTS) but also mortality and direct (non-auditory) tissue damage known as primary blast injury (Finneran and Jenkins 2012). In sea turtles, the lungs and auditory system are considered the most likely site of primary blast injury; however, the US Navy applies a conservative approach of using the GI tract injury threshold for marine mammals for sea turtles also (Finneran and Jenkins 2012). Therefore, the threshold for mortality and primary (non-auditory) blast injury for sea turtles is an (unweighted) SPL of 237 dB re 1 μPa (Finneran and Jenkins 2012). Since no data exist to better estimate the auditory effects of explosive sound sources, the US Navy applies the thresholds for TTS and PTS of low-frequency cetaceans to sea turtles as well (Finneran and Jenkins 2012). Therefore, the TTS threshold for sea turtles is a peak SPL of 224 dB re 1 μPa and the PTS threshold is a peak SPL of 230 dB re 1 μPa (Finneran and

Jenkins 2012). As with marine mammals, the behavioral effects of a single explosive event on sea turtles are likely to be limited to a short lived-startle reaction. If a very conservative approach is desired, the US Navy's sea turtle behavioral disturbance threshold after exposure to multiple, successive underwater impulses might be used: SEL (weighted) of 160 dB re 1 μPa^{2}s (Finneran and Jenkins 2012). This threshold is based on studies that indicate that behavioral disturbance may occur with SPLs of 175 to 179 dB re 1 μPa (which correspond to SELs of 163.6 to 160.4 dB re 1 μPa^{2}s (Finneran and Jenkins 2012).

Table 5-5
Acoustic Thresholds for Physical Injury and Behavioral Disruption in Sea Turtles.

Potential Effect	Threshold
Mortality/Mortal Injury	237 dB_{peak}
Non-lethal Injury	230 dB_{peak}
TTS	224 dB_{peak}
Behavioral Disruption	160 dB SEL_{cum}

Source: Finneran and Jenkins 2012

Fish. While little is known about the specific hearing capabilities of most species subject to consultation in the BA, most fish are able to detect a wide range of sounds from below 50 Hz up to 500 to 1,500 Hz (Popper and Hastings 2009). While these fish would likely be able to detect sounds like a sonic boom, their response to this sound disturbance is unclear. Potential responses to sound disturbance in fish include temporary behavioral changes, stress, hearing loss (temporary or permanent), tissue damage (such as damage to the swim bladder), or mortality (Popper and Hastings 2009). The onset of effects of elevated SPLs can vary depending on the size of the fish, the presence of a swim bladder, and the fish's hearing mechanism (Popper et al. 2014). Pressure waves from impulsive sounds can cause compression and subsequent injury within gas-containing structures (like the swim bladder) and the auditory system of fish (NMFS 2015a). Fish with no swim bladders are expected to have a lower risk (on the order of 100 times less) of injury from impulsive sounds than those with swim bladders (NMFS 2015a). Larger fish are also expected to be less susceptible to injury or death than smaller fish (NMFS 2015a).

Sharks have demonstrated highest sensitivity to low frequency sound (40 Hz to approximately 800 Hz), sensed solely through the particle-motion component of an acoustical field (Myrberg 2001). Free-ranging sharks are attracted to sounds possessing specific characteristics: irregularly pulsed, broad band (attractive frequencies are below 80 Hz) and transmitted without a sudden increase in intensity. Such sounds may be similar to those produced by struggling prey (Myrberg 2001).

The effects of elevated sound levels on fish are evaluated using the current conventional threshold levels used by the US Navy for assessing the effects of explosives on fish as outlined in Table 5-6 based on NMFS 2015a and Popper et al. 2014. These acoustic thresholds were used for analysis of effects on fish for the FE-1 test (US Navy 2017a) and are detailed below. The mortality/mortal injury threshold, peak SPL of 229 dB re 1 μPa, is based on a literature review by Popper et al. (2014). It is important to note that this mortality threshold is based on the distance from the sound source that would be expected to result in only 1% fish mortality. The Northwest Training and Testing BO (NMFS 2015a) does not provide a set threshold for sub-lethal injury effects on fish. The onset of physical injury (non-lethal) is modeled based on the representative weight of the fish species (and age class, if data are available; NMFS 2015a). Since the authors did not provide these calculations for PTS and other references are not available, in this BA we use the TTS threshold as an extremely conservative estimate of the extent of both temporary and permanent non-lethal damage. The threshold criteria for eliciting TTS in fish is 186 dB SEL_{cum} (NMFS 2015a). The threshold for TTS in fish without a swim bladder and for fish with a swim bladder that is not involved in hearing is likely higher than this value (US Navy 2015b); however, we use 186 dB SEL_{cum} as a conservative threshold for all fish species in this BA. While there are little known data supporting a general threshold for behavioral disturbance in fish and the effects from a single impulsive event are likely to be very fleeting, 150 dB_{RMS} has been used in past analyses and is also used in this BA.

Table 5-6
Acoustic Thresholds for Physical Injury and Behavioral Disruption in Fish.

Potential Effect	Threshold
Mortality/Mortal Injury	229 dB_{peak}
Non-lethal Injury (PTS)	Unknown
TTS	186 dB SEL_{cum}
Behavioral Disruption	150 dB_{RMS}

Source: NMFS 2015a

Corals and Mollusks. Corals and mollusks can perceive sounds (Fritzsch et al. 2007; Mooney et al. 2010; Vermeij et al. 2010), but much less than other invertebrates more specialized to produce and sense sounds (e.g., crabs and shrimp; Patek and Caldwell 2005, Waikiki Aquarium and University of Hawai`i-Manoa 2009). Thresholds for damage to auditory sensors are unknown for corals and mollusks. Marine invertebrates are likely only sensitive to water particle motion caused by nearby low-frequency sources, and likely do not sense distant or mid- and high-frequency sounds (US Navy 2015b). While there is some evidence that long-term or very intense sounds may induce stress effects on invertebrates (US Navy 2015), research on the effects of sound on invertebrate species is limited. Long-duration sounds have the potential to mask biologically relevant sounds for marine invertebrates (US Navy 2015). There is some evidence that crustacean and coral larvae use reef sound for orientation during settlement (Vermeij et al. 2010) and elevated sound levels have the potential to mask the natural acoustic cues (US Navy 2015). As for the FE-1 test flight (US Navy 2017a), acute and temporary acoustic exposures such as those associated with FE-2 impacts are likely to have only temporary consequences, if any, for some of the more specialized invertebrates. These impacts could include temporary disruption of feeding or predator avoidance behaviors (Mooney et al. 2010), but such consequences are likely to be inconsequential for the consultation corals and mollusks.

5.1.1.3 Estimation of Elevated Sound Level Effects

If consultation organisms were exposed to elevated SPLs above thresholds for PTS, physical injury or even death could result. If this were to occur, the animals would be subject to “harm” (as defined by the ESA and MMPA) or Level A Harassment. Exposure to SPLs above thresholds for TTS or behavioral thresholds have the potential to temporarily alter hearing abilities or temporarily alter behavior in consultation organisms but would not result in lasting effects or injury. If a consultation organism was impacted by temporary hearing shift or temporary behavioral modification, this could be considered “harassment” or Level B Harassment (as defined under the ESA and MMPA). Here we analyze the chance that these events will occur as a result of the action following the methodology outlined in the FE-1 BA (US Navy 2017a).

Sonic Booms. As discussed above, the FE-2 vehicle may generate sonic booms from shortly after launch to impact at or near Kwajalein Atoll. The initial sonic boom footprint, which is expected shortly after launch, would be a flattened bell shape spreading wider in the direction of flight then constricting again downrange. Sonic boom overpressures will be at a maximum directly under the flight path with rapidly decreasing SPLs moving away from the centerline of the flightpath. The maximum SPL from sonic booms in the BOA is 135 dB (in-water) with a duration of approximately 0.27 second. As the payload approaches Kwajalein Atoll, the maximum SPL will be realized near the point of impact. The maximum SPL near impact is expected to be less than 175 dB (in water) and last approximately 0.075 second for the loudest sounds and 0.27 second for SPLs with peaks below 140 dB.

The maximum in-water SPLs for sonic booms do not exceed the PTS or TTS thresholds for any cetacean, phocid, bird, or sea turtle. There is a potential for behavioral disruption in sea turtles near the payload impact point; however, only 45 km^2 (17 mi^2) would be subject to SPLs of 160 dB sonic boom overpressures. For fish, sonic boom SPLs would not exceed the TTS threshold and would only exceed behavioral disruption threshold over an area of 474 km^2 (183 mi^2) near the payload impact point. An estimated maximum of 17 green turtles and 6 hawksbill turtles may be exposed to SPLs high enough to elicit behavioral response (Table 5-10, methods below). Maximum in-air SPLs from sonic booms will exceed the behavioral disruption threshold for Newell's shearwaters in the BOA. A conservative estimate indicates in-air SPLs may exceed 94 dB re 20 µPa near the ocean surface over 392,581 km^2. If shearwaters were in this area they might exhibit short-duration startle responses; however, no injury or long-term behavioral disturbance would be expected from this short-duration, single event. Newell's shearwater is not known to occur near Illeginni Islet where sonic boom in-air SPLs will approach 149 dB re 20 µPa. No lasting effects from any realized behavioral disruption are expected for any of the consultation organisms. Animals may have a startle response from this short duration sound, but individuals are expected to return to their normal behavior within minutes of exposure with no lasting effects. For these reasons, the effects of sonic booms on consultation organisms are considered insignificant.

Splashdown of Spent Rocket Motors. Based on the expected pressure levels and species thresholds, splashdown of vehicle components results in the highest SPLs in the BOA and will be analyzed further below. Analyses focus on cetaceans and sea turtles as density estimates for many species are available. Very little information regarding consultation fish or bird densities is available for the BOA; therefore, no probability analyses were conducted for most fish or bird species.

Methods. The number of marine mammal and sea turtle exposures to elevated SPL effects from splashdown of components was calculated based on the best known density information for each species and the affect area. Species densities in the Action Area were estimated based on the best available scientific data incorporated in models of the Navy's Marine Species Density Database for the Hawai`i-Southern California Training and Testing Study Area (Hanser et al. 2017). Animal density shapefiles in the Marine Species Density Database were clipped for each motor impact zone for each season (Fall, Winter, Spring, and Summer), an average density for each impact zone was calculated, and the maximum average density across seasons (Table 5-9) was used in elevated SPL analyses. For species where density data did not cover motor impact zones 2 or 3, maximum density values for the western transit corridor (160 to 460 km [99 to 286 mi] from impact zone 2 and 610 to 1,020 km [379 to 634 mi] from impact zone 3) were used (Hanser et al. 2017). In the BOA sea turtles were combined into a "sea turtle guild" in the Marine Mammal Density Database due to the lack of species-specific occurrence data (Hanser et al. 2017). This sea turtle guild is composed of primarily green and hawksbill turtles as they account for nearly all sightings in the study area; however, in theory, the guild also encompasses leatherback, olive ridley, and loggerhead turtles (Hanser et al. 2017).

Density data for fish in the BOA are largely lacking. Based on longline fishery catches, a model has been developed for relative density of bigeye thresher sharks in the Pacific. The highest density of bigeye thresher sharks is between 5 and 15° N (Figure 4-3) where the areas of highest density correspond to a less than 5% chance of encountering more than one shark per km^2 (Fu et al. 2016). Data on the density of other fish species (oceanic whitetip shark, oceanic manta ray, and Pacific bluefin tuna) in the BOA are not available.

These analyses assume that all animals would be at or near the surface 100% of the time and that the animals are stationary. While these assumptions do not account for animals that spend the majority of time underwater or for any animal movement or potential avoidance to proposed activities, these assumptions should lead to a conservative estimate of elevated SPL effects on listed species. The chance of animals being affected by splashdown of spent FE-2 launch vehicle components in the BOA was calculated by the formula:

$$\text{Number of Exposures} = \text{Species Density per km}^2 \times \text{Affect Area in km}^2$$

For payload impact at Illeginni Islet, sounds may propagate into the marine environment, and a similar calculation was used for number of exposures in this area. Marine mammals are not expected to be in the shallow waters near Illeginni Islet which may be exposed to elevated SPLs. Data on sea turtle and fish densities near Illeginni Islet are sparse, and no reliable density data are available for the species in areas addressed in this BA. The US Navy has reported the density of green sea turtles at Guam to be 1 per 3.4 km^2 (1 per 1.3 mi^2) in offshore waters and 1 per 2.6 km^2 (1 per 0.988 mi^2) in nearshore waters; and the density of hawksbill sea turtles at Tinian to be 1 per 7.5 km^2 (1 per 2.88 mi^2; US Navy 2015a). Green turtles are the most common turtles in Kwajalein Atoll, but hawksbill turtles also occur there. Turtle densities are likely to vary greatly, being lower in offshore waters and higher in very productive nearshore waters. For this BA, the best available data are used (Table 5-9). It is important to note that although the best available nearshore density data are used, the density and distribution of sea turtles near Illeginni Islet remains unknown.

As with the BOA, few data are available for fish densities near Kwajalein Atoll. The only comparable reliable density estimate that was found was for the reef manta ray. Data from a long-term study of the insular coral reef ecosystem of Guam resulted in an overall density estimate of less than 0.01 individuals per km^2 (Martin et al. 2016). Densities in this study ranged from 0.0 to 0.03 per km^2 with the highest densities in reef habitats predominantly covered by coral, turf, and macroalgae and in Marine Protected Areas around Guam (Martin et al. 2016).

Radial distances and affect areas for splashdown in the BOA were calculated for mortality/mortal injury, onset of PTS (non-lethal injury), TTS, and behavioral response in consultation organisms based on the calculated SPLs for each component (Table 5-7 and Section 5.1.1.1) and thresholds for each species group (Section 5.1.1.2). An affect area for injury or death from direct contact from falling vehicle components was also calculated (results discussed in Section 5.1.2.2). It is important to note that these SPLs were calculated using conservative assumptions which would lead to the maximum, yet unlikely to be realized, SPLs. Therefore, these estimates should be considered maximum effect estimates for the Proposed Action and are likely overestimates.

While the payload impact will be on land at Illeginni Islet, sounds may propagate into the water. The peak SPL for payload impact (191 dB) does not exceed the PTS or TTS thresholds for any marine mammal or sea turtle. Radial distances and affect areas for payload impact noise were calculated for onset of TTS and behavioral response fish as well as for behavioral disruption in sea turtles based on the SPL source level of 191 dB and using a conical spreading model (Table 5-8). These estimates are likely to be conservatively high and should be considered a maximum affect area.

Results. Based on the above assumptions, the number of animals expected to be exposed to elevated sound levels from splashdown of vehicle components in the BOA was calculated for each marine mammal species and for the sea turtle guild (Table 5-9). While estimated peak SPLs for payload impact would not exceed the PTS and TTS of any marine mammal species, the number of sea turtle exposures was calculated near Illeginni Islet (Table 5-10).

Table 5-7
Maximum Underwater Radial Distance to Threshold and Acoustic Affect Areas for Marine Mammals, Sea Turtles, and Fish from FE-2 Component Splashdowns in the BOA.

Species Group	Effect Category	Criterion (re 1 µPa)	Radial Distance from Spent Motor Impact Point, m (ft)			
			Stage 1	Stage 2	Nose Fairing	Stage 3
High Frequency Cetaceans	PTS (non-lethal injury)	202 dB_{peak}	6.3 (20.7)	1.4 (4.6)	-	-
	TTS	196 dB_{peak}	12.6 (41.3)	2.8 (9.2)	1 (3.3)	1.8 (5.8)
Mid Frequency Cetaceans	PTS (non-lethal injury)	230 dB_{peak}	-	-	-	-
	TTS	224 dB_{peak}	-	-	-	-
Low Frequency Cetaceans	PTS (non-lethal injury)	219 dB_{peak}	-	-	-	-
	TTS	213 dB_{peak}	1.7 (5.8)	-	-	-
Phocids	PTS (non-lethal injury)	218 dB_{peak}	1 (3.3)	-	-	-
	TTS	212 dB_{peak}	2 (6.5)	-	-	-
Birds	PTS (non-lethal injury)	212 dB SEL re 1 μPa^2-s	2 (6.5)	-	-	-
Sea Turtles	Mortality/ Mortal Injury	237 dB_{peak}	-	-	-	-
	PTS (non-lethal injury)	230 dB_{peak}	-	-	-	-
	TTS	224 dB_{peak}	-	-	-	-
	Behavioral Disruption	160 dB_{peak}	794 (2,606)	178 (583)	63.1 (207)	112 (368)
Fish	Mortality/ Mortal Injury	229 dB_{peak}	-	-	-	-
	TTS	186 dB SEL_{cum} re 1 μPa^2-s	39.8 (130.6)	8.9 (29.2)	3.2 (10.4)	5.6 (18.4)
	Behavioral Disruption	150 dB_{RMS}	2,512 (8,241)	562 (1,845)	200 (655)	355 (1,164)

Table 5-8
Estimated Radial Distances and Acoustic Affect Areas for Sea Turtles and Fish from Payload Impact at Illeginni Islet.

Species Group	Effect Category	Criterion (re 1 µPa)	Radial Distance from Impact Point, m (ft)	Affected Surface Area around Impact Point, km^2 (mi^2)
Sea Turtles	Behavioral Disruption	160 dB_{peak}	117 (383)	0.04 (0.02)
Fish	TTS	186 dB SEL_{cum} re 1 μPa^2-s	2.2 (7.1)	0.00001 (0.000006)
	Behavioral Disruption	150 dB_{RMS}	541 (1,775)	0.92 (0.36)

No temporary or permanent physical effects as a result of elevated sound levels are expected for any marine mammals in any portion of the Action Area. The expected SLPs from component splashdown do not exceed PTS or TTS effect thresholds for mid-frequency cetacean species. For low-frequency cetaceans, elevated sound levels only exceed the TTS threshold for splashdown of the spent stage 1 motor. There is only a 1 in $9.8x10^6$ to 1 in $2.0x10^9$ chance (depending on the species) of a low-frequency cetacean being exposed to SPLs great enough to cause TTS. High-frequency cetacean species also have very little chance of being affected by elevated SPLs from splashdown of FE-2 launch vehicle components in the BOA. Splashdown of both the stage 1 and 2 motors may generate SPLs loud enough to exceed the PTS and TTS thresholds in these animals, and the stage 3 motor and nose fairings may generate SPLs that exceed the TTS for high-frequency cetaceans; however, the chances of an individual being exposed are very low (Table 5-9). Overall, there is a 1 in $7.58x10^5$ chance that a high-frequency cetacean would be exposed to SPLs high enough to elicit PTS and a 1 in $1.86\ x10^5$ chance of TTS exposure for high-frequency cetaceans (Table 5-9).

It is important to remember that the model also does not account for animal movement or avoidance behaviors. Cetaceans are highly mobile animals that spend much of their time below the ocean's surface. For all cetacean species, the chances of animals being physically affected by elevated sound levels from splashdown of vehicle components is considered discountable based on these analyses. Because this is a single event, the US Navy does not analyze behavioral effects of the Action since these are expected to occur only once, be extremely short lived, and animals are expected to resume normal behavior quickly. Given the density of cetaceans in the Action Area, the relative hearing abilities of these species, and their mobility, no lasting behavioral effects are expected.

Hawaiian monk seals have a similarly low chance of being affected physically by the elevated SPLs generated by falling FE-2 components in the BOA. Hawaiian monk seals only have the potential to occur in motor drop zone 1. In this area, splashdown of the spent stage 1 motor would have the potential to exceed the PTS threshold for monk seals out to 1 m (3 ft) and would have the potential to exceed the TTS threshold out to 2 m (6 ft). Resulting chances of effect are only 1 in $1.06x10^{10}$ of being exposed to SPLs above the PTS threshold and 1 in $2.67x10^9$ for TTS for Hawaiian monk seals.

Splashdown of FE-2 components will not exceed the acoustic thresholds for mortal injury, PTS, or TTS for sea turtles in the Action Area. Based on the best available density data for sea turtles, there is a slight chance that a sea turtle behavior may be affected by elevated sound pressures in the BOA (Table 5-9). The chance of an individual sea turtle being in the area affected by sound pressures high enough to induce behavioral disturbance in the BOA is 1 in 109 for the five turtle species combined (Table 5-9).

At Illeginni Islet, the chance of an individual green turtle being in the area with payload impact SPLs high enough to induce behavioral disturbance is 1 in 61 (Table 5-10). The chance of a hawksbill turtle being subject to SPLs loud enough to induce behavioral disturbance is 1 in 176. As with cetaceans, it is important to note some of the drawbacks of this model that may lead to overestimation of effect. The model is based on the best available density data. The model assumes that the turtles do not move or exhibit avoidance behaviors to the approaching components. The estimates for the chances of elevated sound levels affecting individual sea turtles are likely overestimated in these analyses; however, these estimates do provide a conservative estimate of effects.

Table 5-9.
Number of Marine Mammal and Sea Turtle Exposures to Acoustic Impacts from FE-2 Launch Vehicle Component Splashdown in the BOA.

Species Name	Motor Drop Zone 1				Motor Drop Zone 2				Motor Drop Zone 3				Total Number of Exposures		
	Density (/km^2) [1]	PTS	TTS	Behav. Disturb.	Density (/km^2) [1]	PTS	TTS	Behav. Disturb.	Density (/km^2) [1]	PTS	TTS	Behav. Disturb.	PTS	TTS	Behav. Disturb.
Balaenoptera acutorostrata	0.00423	-	4.20E-08	-	0.00423	-	-	-	0.00423	-	-	-	-	4.20E-08	-
B. borealis	0.00016	-	1.59E-09	-	0.00016	-	-	-	0.00016	-	-	-	-	1.59E-09	-
B. edeni	0.00012	-	1.23E-09	-	0.00015	-	-	-	0.00012	-	-	-	-	1.23E-09	-
B. musculus	0.00005	-	4.97E-10	-	0.00005	-	-	-	0.00005	-	-	-	-	4.97E-10	-
B. physalus	0.00006	-	5.96E-10	-	0.00006	-	-	-	0.00006	-	-	-	-	5.96E-10	-
Delphinus delphis [2]	0	-	-	-	0	-	-	-	0	-	-	-	-	-	-
Feresa attenuata	0.00440	-	-	-	0.00440	-	-	-	0.00440	-	-	-	-	-	-
Globicephala macrorhynchus	0.00990	-	-	-	0.00300	-	-	-	0.00266	-	-	-	-	-	-
Grampus griseus	0.00470	-	-	-	0.00470	-	-	-	0.00470	-	-	-	-	-	-
Indopacetus pacificus	0.00310	-	-	-	0.00310	-	-	-	0.00310	-	-	-	-	-	-
Kogia breviceps	0.00291	3.64E-07	1.45E-06	-	0.00291	1.82E-08	8.18E-08	-	0.00291	-	2.89E-08	-	3.82E-07	1.56E-06	-
K. sima	0.00714	8.93E-07	3.56E-06	-	0.00714	4.48E-08	2.01E-07	-	0.00714	-	7.09E-08	-	9.38E-07	3.83E-06	-
Lagenodelphis hosei	0.02100	-	-	-	0.02100	-	-	-	0.02100	-	-	-	-	-	-
Megaptera novaeangliae	0.01031	-	1.02E-07	-	0.00250	-	-	-	0.00250	-	-	-	-	1.02E-07	-
Mesoplodon densirostris	0.00086	-	-	-	0.00086	-	-	-	0.00086	-	-	-	-	-	-
Orcinus orca	0.00006	-	-	-	0.00006	-	-	-	0.00006	-	-	-	-	-	-
Peponocephala electra	0.00200	-	-	-	0.00200	-	-	-	0.00200	-	-	-	-	-	-
Physeter macrocephalus	0.00155	-	-	-	0.00132	-	-	-	0.00109	-	-	-	-	-	-
Pseudorca crassidens	0.00471	-	-	-	0.00115	-	-	-	0.00125	-	-	-	-	-	-
Stenella attenuata	0.00679	-	-	-	0.00425	-	-	-	0.00578	-	-	-	-	-	-
S. coeruleoalba	0.00359	-	-	-	0.00573	-	-	-	0.00743	-	-	-	-	-	-
S. longirostris	0.00812	-	-	-	0.00604	-	-	-	0.01024	-	-	-	-	-	-
Steno bredanensis	0.00507	-	-	-	0.00107	-	-	-	0.00083	-	-	-	-	-	-
Tursiops truncatus	0.00745	-	-	-	0.00057	-	-	-	0.00045	-	-	-	-	-	-
Ziphius cavirostris	0.00030	-	-	-	0.00030	-	-	-	0.00030	-	-	-	-	-	-
Neomonachus schauinslandi	0.00003	9.42E-11	3.75E-10	-	NA	-	-	-	NA	-	-	-	9.42E-11	3.75E-10	-
Sea Turtle Guild [3]	0.00430	-		0.00852	0.00430	-	-	0.00048	0.00430	-	-	0.00017	-	-	0.00918

Abbreviations: PTS = Permanent Threshold Shift; TTS = Temporary Threshold Shift.
[1] Density Data Source: Navy's Marine Species Density Database (Hanser et al. 2017).
[2] No data available for density. Species extremely rare in the central Pacific and unlikely to be present in the BOA of the Action Area
[3] Sea turtles were combined into a "sea turtle guild" in the Hawai`i-Southern California Training and Testing Study Area Marine Species Density Database due to the lack of species-specific occurrence data (Hanser et al. 2017). This sea turtle guild is composed of primarily green and hawksbill turtles as they account for nearly all sightings in the study area; however, in theory, the guild also encompasses leatherback, olive ridley, and loggerhead turtles (Hanser et al. 2017).

Table 5-10
Estimated Number of Sea Turtle Exposures to Elevated Sound Pressure Levels for Payload Impact and Sonic Boom at Illeginni Islet.

Species		Density (animals per km^2)	Estimated Animals Exposed to SPLs above Behavioral Disruption Threshold		
			Payload impact	Sonic Boom	Total
Green turtle [1]	*Chelonia mydas*	0.3846	0.0164	20.7684	20.7848
Hawksbill Turtle [1]	*Eretmochelys imbricata*	0.1334	0.0057	7.2036	7.2093

[1] Density Data Source: US Navy 2013.

The density and distribution of Newell's shearwaters in the BOA is largely unknown. While the species is known to forage and rest in the BOA between Kauai and Kwajalein, these birds are likely to occur in low densities with densities and distribution tracking those of their food supplies. While estimates for in-air splashdown SPLs for vehicle components have not been calculated, by subtracting 26 dB from in-water estimates we can get a conservative estimate of in-air SPLs. Using these estimates, in-air splashdown SPLs might exceed the injury threshold for shearwaters over a total area of approximately 0.54 km^2 (0.21 mi^2; for all components) in the BOA but may exceed the behavioral disturbance threshold for these birds over 26,861 km^2. It is not expected that shearwaters would be in the area of physical injury, however some birds might be subject to behavioral disruption. Due to the short-duration of elevated SPLs for this single-event, any behavioral disturbance is expected to be limited to short-term startle responses with no lasting effects.

Since Newell's shearwaters forage at the surface and by diving, birds have the potential to be subject to elevated SPLs underwater as well. Only the stage 1 motor splashdown would produce SPLs above the physical injury threshold for birds and only out 2 m (6.5 ft) from impact. Since these birds spend only a portion of their time underwater, their densities in this area is likely to be very low and it is not expected that any birds would be subject to physical injury form underwater pressures.

There are very few known reliable density estimates for consultation fish species in the BOA or shallow waters near Kwajalein Atoll. These fish species likely have very low densities in these areas with patchy distributions. Based on information above, a maximum density of bigeye thresher sharks in the BOA would be 1 per km^2. In the BOA the maximum radial distances at which fish would be subject to TTS (our baseline for auditory injury) and behavioral disruption from splashdown of spent motors 39.8 m (130.6 ft) and 2.5 km (1.4 nm), respectively (Table 5-7). Even if we assume one bigeye thresher shark per km^2, less than one shark would be exposed to SPLs above the TTS threshold (0.0056 individuals or a 1 in 179 chance) and 21 sharks might be exposed to SPLs above the behavioral disruption threshold. Given that one shark per km^2 is likely a substantial overestimate for bigeye thresher sharks in the BOA, these sharks are not likely to be subject to physical injury. Given the presumed low densities and patchy distributions of other sharks, giant manta rays, and tuna in the BOA, it is also not expected that any individuals would be subject to physical injury. Some fish might be exposed to SPLs above the behavioral disruption threshold; however, due to the short-duration of elevated SPLs for this single-event, any behavioral disturbance is expected to be limited to short-term startle response with no lasting effects.

Near Illeginni Islet, the maximum radial distance at which fish might be subject to injury is only 2.2 m (7.2 ft) and 541 m (1,775 ft) for behavioral disturbance (Table 5-8). Adult fish are not expected to be within 2.2 m (7.2 ft) of payload impact on Illeginni Islet. Even if an estimate of reef manta ray density on the high end of estimated density (0.03 per km^2) is used, less than one manta ray (0.0276 individuals) are estimated to be exposed to SPLs above the behavioral disturbance threshold. Some adult or juvenile humphead wrasse may be exposed to behavioral disturbance from elevated SPLs as well (see Section 5.1.2.2 for estimates). As in the BOA, if fish are exposed to SPLs above the behavioral disturbance threshold, any behavioral disturbance is expected to be limited to short-term startle response.

5.1.1.4 Effect Determinations for Exposure to Elevated Sound Levels

Broad Ocean Area. The scalloped hammerhead shark, reef manta ray, adult humphead wrasse, adult corals, adult mollusks and one cetacean species (Table 4-2) do not or are not likely to occur in the BOA and, therefore, will not be affected by any elevated sound levels in the BOA.

Elevated sound levels would have no effect on listed marine mammal, sea turtle, bird, or fish species in the BOA based on the following:

- Underwater sound levels would not exceed thresholds for PTS or TTS for any mid-frequency cetaceans or sea turtles in the BOA;
- The calculated chances of an individual low-frequency cetacean, high frequency cetacean, or Hawaiian monk seal being exposed to sounds above the injury thresholds (TTS or PTS) are so low as to be discountable (see analysis in Section 5.1.1.3);
- The calculated chances of an individual sea turtle being exposed to sound above the behavioral disturbance threshold are also so low as to be discountable;
- Due to the low densities and patch distribution of consultation fish and birds along the projected flight path, it is very unlikely that these organisms would be affected; and
- In the very unlikely instance that a consultation species were exposed to elevated SPLs, any realized reaction would likely be temporary due to the short duration (less than 1 second) of potential exposure to elevated noise. There is no reason to expect that there would be any significant or lasting physiological or fitness effects or that animal behaviors would not return to normal within minutes of the disruption.

At certain times of the year the gametes and larvae of some reef-associated fish, coral, and mollusk species may occur as zooplankton within the boundaries of the drop zones (Figure 3-2). However, it is extremely unlikely that these shallow-water reef-associated larvae would occur in spent motor drop zones because they are so far up current from sources of larvae. Elevated sound levels would not affect individual larval fish, corals, or mollusks for the following reasons:

- Larvae respond to sound, but limited evidence available suggests that their behavior is negatively affected only by chronic noise, not by acute sounds;
- If affected, their behavior is likely to be temporarily affected and will return to normal after a brief interval: and
- Larval fish, corals, and mollusks likely have very low densities in the BOA.

Vicinity of Illeginni Islet. Sonic boom accompanying each payload would generate peak underwater pressures near Illeginni Islet of 180 dB re 1 µPa at the water surface and lasting about 270 ms. Impact of the payload at Illeginni Islet would generate peak in-water sound pressures of 191 dB lasting no more than a couple of seconds.

Most cetacean species (≥15; Table 4-2), the Hawaiian monk seal, Newell's shearwater, 3 sea turtle species (Table 4-4), and 3 fish species (Table 4-5) do not occur in the immediate vicinity of Illeginni Islet and therefore would not be affected by elevated sound levels in this area.

Cetaceans would not be affected by elevated SPLs near Illeginni Islet. Elevated SPLs from payload impact will not affect any cetacean species as these species are not found in the shallow waters subject to elevated SPLs. Sonic boom overpressures along the payload flight path would not exceed PTS, or TTS thresholds for any marine mammal species. In the very unlikely instance that an individual cetacean were exposed to elevated SPLs, any realized behavioral response would be limited to temporary reactions with no significant or long-term effects.

Elevated SPLs may affect, but are not likely to adversely affect, consultation sea turtles or fish near Illeginni Islet. Any realized affects would likely be limited to temporary behavioral effects with no significant or lasting adverse effects, based on the following:

- Sound levels would not exceed thresholds for injury, PTS or TTS for any consultation organism in the waters near Illeginni Islet;
- Sound levels would exceed the behavioral disruption threshold for sea turtles with an estimated 20 green turtles and 7 hawksbill turtles being exposed. However, any realized the effects would likely be limited to temporary behavioral reactions due to the short duration of potential exposure with no physiologically significant or long term effects; and
- While some consultation fish are likely to be exposed to SPLs above the behavioral disturbance threshold, any realized response would likely be limited to temporary behavioral effects and fish would be expected to return to normal behavior within minutes of exposure with no significant or lasting effects.

Although densities of larval fish, coral, and mollusks have the potential to be higher in the shallow waters surrounding Illeginni Islet, elevated SPLs in the area would have no adverse effect on larval fish, corals and mollusks. Larval fish, corals, and mollusks, while present in shallow waters near Illeginni Islet, are episodic in their presence with peak abundance during spawning season between July and December. Adult corals and mollusks are expected to respond behaviorally to acute sounds, if at all and are not expected to be affected by elevated SPLs as a result of the Action. Any modification of behavior is likely to be temporary, and behavior will return to normal after a brief interval.

5.1.2 Direct Contact

The Proposed Action will result in spent rocket motors and payload fairings splashing down into the BOA as well as impact of the payload on land at Illeginni Islet. These falling components will directly impact aquatic and/or terrestrial habitats and have the potential to directly contact consultation organisms. The force of impact for these vehicle and/or payload components contacting land or the ocean surface may result in ejecta and/or shock waves radiating out from the point of impact. While direct estimates for shock-wave strength and cratering are not available for the FE-2 test flight, cratering and shock waves are expected to be less than those of MMIII RVs. As in analyses for FE-1, MMIII estimates of cratering and shock waves (USAFGSC and USASMDC/ARSTRAT 2015) are used as a maximum bounding case for the Proposed Action. Shock-wave pressures are discussed in Section 5.1.1, Exposure to Elevated Sound Levels.

5.1.2.1 Sources of Direct Contact

Splashdown of Components in the BOA. Spent rocket motors from the three stages of the FE-2 launch vehicle will splash down into the BOA (Figure 3-2). The nose fairing connecting the payload to the third stage motor is expected to fall into the second spent motor drop zone.

As described in Section 3.2.1, the first stage motor is 4.62 m (182 in) long with a diameter of 1.37 m (54 in) with an additional interstage section that is 87.12 cm (34.3 in) long with a diameter of 1.37 m (54 in). The second stage motor is 2.26 m (89 in) long with a diameter of 1.37 m (54 in), and the third stage motor is 1.32 m (52 in) long with a diameter of 1.37 m (54 in). Direct contact areas for these individual components are listed in Table 5-2 and total approximately 61 m^2 (189 square feet [ft^2]).

Impact of Payload on Illeginni Islet. The payload impact on Illeginni Islet is the preferred alternative for the FE-2 test flight. For this terrestrial impact on Illeginni Islet, the payload would likely form a crater including ejecta spreading out from the crater. The designated impact zone is an area approximately 290 m (950 ft) by 137 m (450 ft) on the northwest end of Illeginni Islet (Figure 3-4), as limited by available land mass. The footprint of a payload impact on land would be roughly elliptical, but its size would depend on the precise speed of the payload and its altitude. Since speed, altitude, and size information are not available for a payload impact, FE-1 analyses used estimates of reentry vehicle cratering from MMIII test flights (USAFGSC and USASMDC/ARSTRAT 2015) as a bounding case for potential impacts. We use the estimates of cratering from MMIII and FE-1 for the Proposed FE-2 Action as described below.

For MMIII RVs, the ejecta field from crater formation at impact was expected to cover a semicircular area (approximately 120º) extending 60 to 91 m (200 to 300 ft) from the impact, and the density of ejecta was expected to decrease with distance from the point of impact (USAFGSC and USASMDC/ ARSTRAT 2015). Craters from MMIII RVs have been documented to be 6 to 9 m (20 to 30 ft) in diameter and 2 to 3 m (7 to 10 ft) deep.

The payload is planned to impact on Illeginni Islet within the designated impact zone (Figure 3-4). While not planned, a shoreline impact has the potential to affect sea turtle nesting habitat. It is possible that a payload impact on the shoreline at Illeginni would affect the nearshore marine environment through ejecta from a crater and/or falling fragments.

5.1.2.2 Estimation of Direct Contact Effects

Cetaceans, Sea Turtles, Birds and Fish in the BOA. If a spent rocket motor or other FE-2 component were to strike a cetacean, bird, sea turtle, or fish near the water surface, the animal would most likely be killed or injured. Based on the above discussed affect areas, and the best available species density information, chances of direct contact to cetaceans and sea turtles in the BOA were calculated. Calculations were based on methodology in the FE-1 EA (US Navy 2017b), Mariana Islands Training and Testing Activities Final EIS (Appendix G in US Navy 2015a), and the Hawai`i-Southern California Training and Testing EIS (Appendix G in US Navy 2013). Very little information regarding bird or fish densities is available for the BOA; therefore, direct contact probabilities were not calculated for bird or most fish species.

Methods. A probability of direct contact and total number of exposures was calculated for each marine mammal species and for a sea turtle guild for each FE-2 component based on component characteristics and animal density in the Action Area. The probability analysis is based on probability theory and modified Venn diagrams with rectangular "footprint" areas for the individual animals and the component impact footprints within the Action Area. Species densities in the Action Area were estimated based on the best available scientific data incorporated in models of the Navy's Marine Species Density Database for the Hawai`i-Southern California Training and Testing Study Area (Hanser et al. 2017) as in Section 5.1.1.3. Sea turtles were combined into a "sea turtle guild" for analyses due to the lack of species specific occurrence data (Hanser et al. 2017). This sea turtle guild is composed of primarily green and hawksbill turtles as they account for nearly all sightings; however, in theory, the guild also encompasses leatherback, olive ridley, and loggerhead turtles (Hanser et al. 2017). These analyses assume that all animals would be at or near the surface 100% of the time and that the animals are stationary. While these assumptions do not account for animals that spend the majority of time underwater or for any animal movement or potential avoidance to proposed activities, these assumptions should lead to a conservative estimate of direct contact effect on listed species.

Direct contact probability methods are modified from those used by the US Department of the Navy for other environmental analyses (US Navy 2013, US Navy 2015a, US Navy 2017a). Variables and variable calculations are summarized in Table 5-11.

Table 5-11.
Variables Used in Direct Contact Probability Calculations.

Variables	Definition and Units	Calculation
A	Individual Animal Footprint (km^2)	$= L_a * W_a$
A_{buffer}	Buffered Animal Footprint (km^2)	= 0.5*I
d_C	Diameter of component (km)	
D	Species Density in the Action area (per km^2)	
E	Number of Exposures	=N*P
I	Component Impact Footprint (km^2)	$= l_C * d_C * N_C$
P	Probability	= T/R
l_C	Length of component (km)	
L_a	Length of Individual Animal (km)	
L_i	Length of Impact (km)	$= W_i * \left(\frac{W_a}{L_a}\right)$
N	Number of animals in the Action Area	=D*R
N_C	Number of each component	
r_a	Radius of Animal Footprint (km)	$= \sqrt{\frac{(L_a * W_a)}{\pi}}$
r_i	Radius of Impact Area (km)	$= \sqrt{\frac{(0.5 * L_i * W_i)}{\pi}}$
R	Action Area (km^2)	
T	Total Area of A and I overlap	
W_a	Width of Individual Animal (km)	= 20% of L_a for marine mammals =112% of L_a for sea turtles
W_i	Width of Impact (km)	$= \frac{I}{2L_i} = L_i * \left(\frac{W_a}{L_a}\right)$

Source: Calculations as in US Navy 2013 and US Navy 2015a.

For each marine mammal species and for the sea turtle guild, individual animal "footprints" (A) were estimated using A = *animal length* (L_a)**animal width* (W_a), where animal width (breadth) is assumed to be 20% of its length for marine mammals and 112% of its length for sea turtles. The number of animals (N) in the Action Area was calculated as the product of the highest average seasonal animal density (D) and the Action Area (R): $N = D*R$. For purposes of estimating density and for calculating direct contact probability, the Action Area (R) was considered to be the spent motor drop zones in the BOA (Figure 3-2). Animal density (D) in the Action Area was estimated based on the best available scientific data incorporated in models of the Navy's Marine Species Density Database (Hanser et al. 2017) as in the estimation of effects of elevated sound pressures as described in Section 5.1.1.3, Estimation of Elevated Sound Level Effects.

The likelihood of an impact from FE-2 component splashdown in deep ocean waters was calculated as the probability (*P*) that an individual animal footprint (*A*) and the impact footprint (*I*) for a component will intersect within the Action Area (*R*). This probability is calculated as the area ratio *A/R* or *I/R*, respectively. The impact footprint (*I*) refers to the impact footprint for each component calculated separately as: *I*=component length (l_C)*component diameter (d_C)*number of each component (N_C). Since only one of each component will be used for the FE-2 fight test, $N_C = 1$ for all components and $I=l_C*d_C$. The probability that a random point in the Action Area is within both the animal footprint (*A*) and impact footprint (*I*) depends on the degree of overlap of *A* and *I*. The probability that *I* overlaps *A* is calculated by adding a buffer distance around *A* based on one-half of the impact area ($A_{buffer} = 0.5*I$), such that an impact center occurring anywhere within the combined (overlapping) area would impact the animal. To account for the buffer and achieve similar geometry between the animal footprint and the impact footprint, the length (L_i) and width (W_i) of the impact footprint are defined by $W_i/L_i = W_a/L_a$ and $L_i*W_i = 0.5*I$. The total overlapping areas (*T*) of *A* and *I* (including the buffer area) and the buffer areas were defined for four scenarios:

- **Scenario 1:** Static and rectangular scenario where the impact is assumed to be static (i.e. direct impact effects only; no explosions or scattering of debris after the initial impact), $T = (L_a + 2*L_i)* (W_a + 2*W_i)$, and $A_{buffer} = T – L_a*W_a$.

- **Scenario 2:** Dynamic scenario with end-on collision where the length (L_i) of the impact footprint is enhanced by 5 lengths of the component (l_C)to reflect forward momentum, $T = (L_a + (2*(Li+(5*l_C))))* (W_a + 2*W_i)$, and $A_{buffer} = T – L_a*W_a$.

- **Scenario 3:** Dynamic scenario with broadside collision where the width (W_i) of the impact footprint is enhanced by 5 lengths of the component (l_C) to reflect forward momentum, $T = (L_a + 2* L_i)* (W_a + (2*(Wi+(5* l_C))))$, and $A_{buffer} = T – L_a*W_a$.

- **Scenario 4:** Static and radial scenario where the rectangular animal and impact footprints are replaced with circular footprints while conserving area. The animal footprint radius (r_a) = $\sqrt{\frac{(L_a*W_a)}{\pi}}$, the impact footprint radius (r_i) = $\sqrt{\frac{(0.5*L_i*W_i)}{\pi}}$,
the total overlapping area $(T) = \pi * (r_a + r_i)^2$, and $A_{buffer} = T – \pi*r_a^2$.

Static impacts (Scenarios 1 and 4) assume no additional areal coverage effects beyond the initial impact. For dynamic impacts (Scenarios 2 and 3), the distance of scattered components or debris must be considered by increasing the length (Scenario 2) or width (Scenario 3) depending on entry orientation, to account for forward momentum. Forward momentum typically accounts for five object lengths, resulting in a corresponding increase in impact area.

Impact probability (*P*) is the probability of impacting one animal with the given number (in the case of this BA there is only one of each component) and type of component and is given by the ratio of total area (*T*) to the Action area (*R*): $P = T/R$. Number of exposures (*E*) is $E=N*P$, where *N* is the number of animals in the Action Area in a given year (calculated as the product of the animal density and Action Area size).

Using this logic, probability (*P*) and total exposures (*E*) were calculated for each of the four scenarios, for each marine mammal or sea turtle species, and for each FE-2 component. The scenario-specific *P* and *E* values were averaged over the four scenarios (using equal weighting) to obtain a single scenario-averaged estimate of *P* and *E* (Table 5-12).

Results. Based on several assumptions (discussed above), the estimated chance of a marine mammal individual exposure to direct contact from falling FE-2 components in the BOA is between 1 in 109,000 and 1 in 19,500,000 depending on individual species (Table 5-12). While we have included all possible species in these analyses with maximum average density estimates from other areas of the Pacific Ocean, it is important to note that many of these species are extremely unlikely to occur in the BOA of the Action Area during certain times of the year. The estimated chance of a Hawaiian monk seal exposure to direct contact from falling FE-2 components is 1 in 166,000,000. Even when totaled across species, the estimated chance of any marine mammal exposure is only 1 in 19,300. The model does not account for animal movement or avoidance behaviors. Cetaceans are highly mobile and spend a large portion of their time moving below the ocean's surface. The exposure estimates were modeled based on conservative assumptions and are likely result an overestimation of the probability of effect. For all cetacean species, the chances of animals being physically injured from direct contact from splashdown of vehicle components is considered so low as to be discountable based on these analyses. For a land impact at Illeginni Islet, there would be no chance of direct contact from falling fragments on cetaceans.

Based on the best available density data for sea turtles, the estimated chance of animal exposure to direct contact from falling FE-2 vehicle components in the BOA is 1 in 710,000 (Table 5-12). As with cetaceans, it is important to note some of the drawbacks of this model that may lead to overestimation of effect. The model is based on the best available density data. Since many density studies of turtles are conducted in nearshore areas, density estimates in deep ocean areas are largely unknown. The model also assumes that the turtles do not move and are at the surface 100% of the time.

While density estimates are not available for most fish species found in the BOA, densities of these species are likely to be low and distributions patchy. The most reliable density estimates are for bigeye thresher sharks. A spatial model of relative density based on longline fishery catches indicated that even in the areas of highest density, there is a less than 5% chance of encountering more than one shark per km^2 (Fu et al. 2016). Even if a density of one bigeye thresher shark per km^2 is used for direct contact analysis, the average total animals expected to be exposed to direct contact by FE-2 components in the BOA is 2.7×10^{-4}. A density of one shark per km^2 is likely a very high estimate for the density of bigeye thresher sharks in the BOA, and this should be considered a very conservative, maximum estimate.

Table 5-12.
Probability of Direct Contact from FE-2 Vehicle Components and Estimated Number of Marine Mammal and Sea Turtle Exposures in the BOA.[1]

	Average Probability of Impacting One Animal Across Scenarios based on Animal and Component Size				Average Number of Exposures Across Scenarios (number of animals)				Estimated Total Number of Exposures
Species/ Group	1st Stage Motor	2nd Stage Motor	Nose Fairing	3rd Stage Motor	1st Stage Motor	2nd Stage Motor	Nose Fairing	3rd Stage Motor	
Marine Mammals									
Balaenoptera acutorostrata	3.18E-08	1.98E-09	3.24E-09	7.09E-10	1.56E-06	6.31E-07	1.03E-06	3.96E-07	3.62E-06
B. borealis	4.90E-08	3.49E-09	5.27E-09	1.37E-09	9.10E-08	4.21E-08	6.37E-08	2.90E-08	2.26E-07
B. edeni	4.56E-08	3.18E-09	4.86E-09	1.24E-09	6.56E-08	3.55E-08	5.43E-08	1.89E-08	1.74E-07
B. musculus	8.72E-08	7.23E-09	1.00E-08	3.15E-09	5.06E-08	2.73E-08	3.77E-08	2.08E-08	1.36E-07
B. physalus	6.84E-08	5.34E-09	7.65E-09	2.23E-09	4.77E-08	2.42E-08	3.46E-08	1.77E-08	1.24E-07
Feresa attenuata	1.78E-08	8.80E-10	1.66E-09	2.66E-10	9.09E-07	2.92E-07	5.50E-07	1.54E-07	1.91E-06
Globicephala macrorhynchus	2.30E-08	1.27E-09	2.24E-09	4.20E-10	2.65E-06	2.88E-07	5.07E-07	1.47E-07	3.59E-06
Grampus griseus	1.85E-08	2.50E-09	3.96E-09	9.36E-10	2.07E-06	8.88E-07	1.40E-06	5.81E-07	4.94E-06
Indopacetus pacificus	2.98E-08	1.81E-09	3.01E-09	6.39E-10	1.07E-06	4.24E-07	7.03E-07	2.62E-07	2.46E-06
Kogia breviceps	1.94E-08	9.98E-10	1.83E-09	3.11E-10	6.55E-07	2.19E-07	4.02E-07	1.19E-07	1.40E-06
K. sima	1.80E-08	8.93E-10	1.67E-09	2.70E-10	1.49E-06	4.81E-07	9.02E-07	2.55E-07	3.13E-06
Lagenodelphis hosei	1.80E-08	8.93E-10	1.67E-09	2.70E-10	4.38E-06	1.42E-06	2.65E-06	7.50E-07	9.20E-06
Megaptera novaeangliae	4.90E-08	3.49E-09	5.27E-09	1.37E-09	5.86E-06	6.58E-07	9.95E-07	4.54E-07	7.97E-06
Mesoplodon densirostris	2.40E-08	1.35E-09	2.35E-09	4.49E-10	2.39E-07	8.75E-08	1.52E-07	5.09E-08	5.30E-07
Orcinus orca	3.18E-08	1.98E-09	3.24E-09	7.09E-10	2.21E-08	8.95E-09	1.47E-08	5.62E-09	5.13E-08
Peponocephala electra	1.80E-08	8.93E-10	1.67E-09	2.70E-10	4.17E-07	1.35E-07	2.53E-07	7.14E-08	8.76E-07
Physeter macrocephalus	4.45E-08	3.08E-09	4.73E-09	1.19E-09	8.00E-07	3.06E-07	4.70E-07	1.72E-07	1.75E-06
Pseudorca crassidens	2.40E-08	1.35E-09	2.35E-09	4.49E-10	1.31E-06	1.17E-07	2.03E-07	7.43E-08	1.71E-06
Stenella attenuata	1.68E-08	8.04E-10	1.54E-09	2.37E-10	1.32E-06	2.58E-07	4.93E-07	1.81E-07	2.25E-06
S. coeruleoalba	1.80E-08	8.93E-10	1.67E-09	2.70E-10	7.49E-07	3.86E-07	7.24E-07	2.65E-07	2.12E-06
S. longirostris	1.68E-08	8.04E-10	1.54E-09	2.37E-10	1.58E-06	3.67E-07	7.02E-07	3.20E-07	2.97E-06
Steno bredanensis	1.78E-08	8.80E-10	1.66E-09	2.66E-10	1.05E-06	7.10E-08	1.33E-07	2.91E-08	1.28E-06
Tursiops truncatus	2.03E-08	1.07E-09	1.93E-09	3.37E-10	1.76E-06	4.61E-08	8.36E-08	2.00E-08	1.90E-06
Ziphius cavirostris	2.59E-08	1.50E-09	2.56E-09	5.09E-10	9.01E-08	3.39E-08	5.80E-08	2.02E-08	2.02E-07
Neomonachus schauinslandi	1.73E-08				6.02E-09				6.02E-09
Total Marine Mammal Exposures					**2.92E-05**	**6.68E-06**	**1.18E-05**	**4.01E-06**	**5.17E-05**
Sea Turtles									
Sea Turtle Guild [2]	1.55E-08	6.70E-10	1.25E-09	2.04E-10	6.70E-07	2.17E-07	4.06E-07	1.16E-07	1.41E-06

[1] Animal densities used for analyses are presented in table 5-9. The first stage motor would splashdown in motor drop zone 1, the second stage motor and nose fairings in motor drop zone 2, and the third stage motor in motor drop zone 3.

[2] Sea turtles were combined into a "sea turtle guild" in the Marine Species Density Database due to the lack of species specific occurrence data (Hanser et al. 2017). This sea turtle guild is composed of primarily green and hawksbill turtles as they account for nearly all sightings in the study area; however, in theory, the guild also encompasses leatherback, olive ridley, and loggerhead turtles (Hanser et al. 2017).

Sea Turtles and Sea Turtle Nests on Illeginni Islet. Only green sea turtles and hawksbill turtles have been observed near Kwajalein Atoll islets. These two species are known to nest or haul out on some Kwajalein Atoll Islets. If a sea turtle or sea turtle nest were struck by debris or ejecta from payload impact, a sea turtle could be killed or injured, or sea turtle eggs could be damaged or destroyed. Turtles also have the potential to be subject to behavioral disruption significant enough to preclude females from haul-out and nesting.

In the Marshall Islands, sea turtle nesting generally occurs between May and November. Based on available information, NMFS and USFWS (2015) estimated 300 nesting green turtle females in the RMI out of a total of 6,500 nesting females in the Central West Pacific DPS (4.6% of the known breeding population). In a 2008 survey of USAKA, suitable nesting habitat (relatively open sandy beaches and seaward margins of herbaceous strand above tidal influence) for sea turtles was identified at Illeginni Islet (Figure 4-2 and Figure 5-1). These areas were thoroughly surveyed on foot for turtles, nesting pits, and tracks, but no activity was observed. These nesting and haulout habitats were reevaluated during the 2010 inventory and were determined to still be suitable habitat; however, no sea turtle nests or nesting activity have been observed on Illeginni in over 20 years. Sea turtle nest pits (unidentified species) were last found on Illeginni Islet in 1996, on the northern tip of the islet.

Known green sea turtle activity in the vicinity of Illeginni Islet is limited to an adult green turtle seen in nearshore waters on the ocean side of Illeginni in 1996 (USFWS and NMFS 2002), four turtles observed in the 2010 inventory (USFWS and NMFS 2012), one turtle observed in 2012, and one green turtle recorded during the 2014 inventory (NMFS and USFWS 2017). Most of the reported observations listed above were made during single-day surveys that were part of biennial resource inventories. These surveys were very limited in scope and effort, lasting for only a few hours and usually done by three people. The low number of sightings near Illeginni Islet may be attributed to the low level of effort expended to observe sea turtles there.

Known hawksbill sea turtle activity in the vicinity of Illeginni Islet is limited to a hawksbill observed near shore in the lagoon north of Illeginni in 2002 (USFWS and NMFS 2004), an adult observed during a 2004 marine survey of an area extending over the lagoon-facing reef northwest of the harbor to a point across from the northwestern corner of the islet, and an adult hawksbill observed in the outer lagoon reef flat.

A shoreline payload impact is not planned or expected, however, there is a chance that this will occur or that debris or ejecta from an impact further inland will affect sea turtle nesting habitat near the shoreline, as debris and ejecta may extend out 91 m (300 ft) from the point of impact. If these nesting habitats are affected, sea turtles may be adversely affected by damage or destruction of sea turtle eggs if nests are present. While Illeginni Islet has shoreline habitat suitable for sea turtle nesting, no sea turtle nests or nesting activity has been observed on Illeginni in over 20 years. The last evidence of sea turtle nesting activity on Illeginni Islet consisted of observation of nest pits (unidentified species) in 1996, 22 years ago. Therefore, we conclude that the probability of sea turtle nesting in the Action Area is so low as to be discountable.

Mitigation measures will be employed to decrease the chances of there being effects on sea turtles or sea turtle nests. For at least 8 weeks preceding the FE-2 launch, Illeginni Islet would be surveyed by pre-test personnel for sea turtles, sea turtle nesting activity, and sea turtle nests. If possible, personnel will inspect the area within two days of the launch. Pre-test personnel at Illeginni Islet and in vessels traveling to and from Illeginni Islet will look for and report any observations of sea turtles, evidence of sea turtle haul out or nesting, or of sea turtle nests at or near Illeginni Islet.

Larval Fish, Corals, and Mollusks. Direct contact or shock waves from splashdown of rocket components may affect and are likely to adversely affect individual larval fish, corals or mollusks that may be present as components of drifting plankton. However, estimates of potential incidental take of consultation species larvae would have to include a margin of error of several orders of magnitude. In studies of larval coral density, samples taken in the same area only minutes apart show differenced in larval density on the order of thousands per 100 m^3 (Hodgson 1985). Even if reliable density data existed for the Action Area, the distribution of larval organisms is likely to be so variable in space and time that accurate estimates of potential incidental take of larval consultation species would have to be based on samples taken at the precise time and location of splashdown of payload components.

A study of coral larvae density during the peak spawning period reported an average abundance of 0.3 planktonic larvae per m^3 across samples from the inner reef flat to 20 m (66 ft) seaward of the reef (Hodgson 1985). Larval densities are generally higher nearer to the reef and decrease as distance increases. These larval densities depend on conditions including ocean currents and seasonality. The area of potentially lethal effect from splashdown of all vehicle components in the BOA combined is less than 30 square meters (m^2) at the sea surface. It is possible that a very low number of fish, coral, or mollusk larvae will be within the affected volume of surface water. Near Illeginni Islet the area of potentially lethal effect from payload splashdown is less than 13,008 m^2 (0.005 mi^2). While larval densities would be higher in these nearshore areas than in the BOA, larval densities still depend on conditions and seasonality. Therefore, splashdown of spent motor stages and payload impact may affect and is likely to adversely affect a very small, but indeterminable, number of larval fish, corals or mollusks.

In general, the consequences of taking individual larvae are considered to be substantially less severe than the consequences of taking individual adults because the baseline mortality rate of larvae is several orders of magnitude higher than for adults; therefore, the odds of individual larvae surviving to reproductive age are substantially lower than the odds of an adult surviving to reproduce again (Gascoigne and Lipcius 2004). Population effects to consultation species are discountable for this reason; because the affected area is trivially small relative to the distribution of these invertebrates; and because the number of larvae potentially affected is likely to be trivially small relative to their population sizes and the effects are considered discountable.

Non-larval Fish, Corals, and Mollusks near Illeginni Islet. Non-larval forms of 22 coral species, 3 fish species, and 5 mollusk species have the potential to occur on the reefs and waters in the vicinity of Illeginni Islet. Presence of these species include the adults of relevant coral and mollusk species and adults and juveniles of the relevant fish species. Of these species, only seven coral species, three mollusk species, and one fish species are known to occur in the area that has the potential to be subject to direct contact from FE-2 payload impact at Illeginni (see methods below). Although coral reefs are not planned or expected to be targeted, a land payload impact on the shoreline of Illeginni could result in ejecta/debris fall, shock waves, and post-test cleanup operations, which may affect and will likely adversely affect at least some of the consultation fish, coral and mollusk species on the adjacent reef. Attempts will be made to avoid payload impact near these sensitive shoreline areas; however, here we analyze this worst-case scenario to elucidate the maximum effects of the Proposed Action.

Methods.

Estimation of Affect Area and Habitat. While coral reefs are not targeted for the FE-2 test, a payload land strike on or near the shoreline could result in ejecta/debris fall and shock wave effects, which have the potential to adversely affect at least some of consultation fish, coral, and mollusk species on the adjacent reef. Mortality or injury could occur from impact by ejecta/debris fall. Empirical observations of historical reentry vehicle impacts from MMIII tests in very shallow waters found that most debris was contained within the crater and ejecta were concentrated within 1.5 to 3 m (5 to 10 ft) of the crater rim (USAFGSC and USASMDC/ARSTRAT 2015). As with MMIII RVs and the FE-1 payload, we estimate that the FE-2 payload land impact may produce ejecta and debris concentrated near the impact site and extending outward to 91 m (300 ft). Empirical evidence from MMIII tests corroborates predictions of the propagation of shock waves approximately 37.5 m (123 ft) through the adjacent reef from the point of impact on the shoreline (USAFGSC and USASMDC/ARSTRAT 2015). Coral, mollusk, and fish mortality or injury could occur from impact by shock/vibration. It is important to note that these reef impacts were based on observations of damaged corals, which can be affected by ground borne vibration.

Therefore, the anticipated worst-case scenario of a payload land impact at Illeginni islet is considered to be a shoreline strike, which would result in debris fall and shock wave effects within an affected area that would extend outward from the point of strike. On both sides of Illeginni Islet, the area potentially affected by shock waves is encompassed within the area potentially affected by debris fall (Figure 5-1). Since these areas overlap and since harmed individuals should be counted only once in the effects of the Action, the affected habitat area with the largest estimated take should be selected as the worst-case scenario. The debris fall affect area is larger than the shock wave affect area; therefore, we calculated the effects of the Action based on the debris fall/ejecta area. Although the exact shape of the affect area is impossible to predetermine, the seaward portion of such an area is conceptually illustrated as a rough semi-circle on the lagoon and ocean sides of Illeginni Islet with a radius of 91 m (299 ft) (Figure 5-1).

Figure 5-1. Representative Maximum Direct Contact Affect Areas for a Shoreline Payload Impact at Illeginni Islet, Kwajalein Atoll.

The aerial extent of potential debris fall effects on the lagoon and ocean sides of Illeginni were calculated to be ½ (πr^2) or 13,008 m^2 (15,557 yd^2). Each of these areas (Figure 5-1) would be subject to potential debris fall based on debris fall distance analyses for similar impacts of the MMIII RVs

(USAFGSC and USASMDC/ARSTRAT 2015) and the FE-1 payload (US Navy 2017a). Based on the best professional judgment of NMFS survey divers, approximately 80% or 10,406 m^2 (12,445 yd^2) of the lagoon-side affect area (Figure 5-1) is considered potentially viable habitat for consultation fish, coral, and mollusks (NMFS-PIRO 2017c). Similarly, approximately 75% or 9,756 m^2 (11,668 yd^2) of the ocean-side affect area (Figure 5-1) is considered potentially viable habitat for consultation fish, coral, and mollusk species (NMFS-PIRO 2017c).

It is reasonable to assume that the effects of debris fall and shock waves would not occur evenly across an entire area of potentially viable habitat. Thus, the actual habitat area that would be affected is considered to be a proportion of the total estimated viable habitat. Since there are no data available to identify this unknown proportion or the actual amount of viable habitat that would be affected by debris fall or shock waves, these analyses assume that the entire area will be affected and should be regarded as an overestimate and those of maximum effect.

Species Density Estimates. Analyses of effect of MMIII reentry vehicles (USAFGSC and USASMDC/ARSTRAT 2015) and FE-1 payload impact (US Navy 2017a) at Illeginni Islet were conducted based on coral, mollusk, and fish densities extrapolated from coral presence and abundance from similar reef habitats throughout USAKA. In 2017, NMFS-PIRO completed a report with revised density estimates for many consultation species based on 2014 assessments of the reefs adjacent to the impact area at Illeginni Islet (NMFS-PIRO 2017a and 2017b). The areas surveyed for this assessment encompassed all of the Affect Area reef habitat on the lagoon side and 99% of the reef area on the ocean side (NMFS-PIRO 2017a and 2017b). Based on coverage area of this assessment, these data are considered the best available information for coral and mollusk species presence and density in the affect area at the time the analysis in this BA was completed.

The humphead wrasse (*Cheilinus undulatus*) was not observed during the 2014 surveys for the most recent assessment of consultation organisms at Illeginni Islet (NMFS-PIRO 2017a); however, this species has been recorded in both ocean-side and lagoon-side habitats adjacent to the impact area in other surveys. Since the humphead wrasse is a highly mobile species, the extrapolation methods for estimating density which were previously used for impact analysis are still considered the best available data for a conservative approach. Therefore, humphead wrasse densities were estimated by NMFS Pacific Islands Regional Office (NMFS-PIRO) based on quantitative data collected during the 2008 species inventory, recent impact assessments on natural substrates at USAKA and, for egg and fish recruit derivations, from the literature (NMFS-PIRO 2014b). *Cheilinus undulatus* typically occurs in broadly distributed low numbers and has been seen near Illeginni islet. It is possible that and estimated 8 adults may occur within the entire potential ocean-side affect area, and 0 to 100 juveniles may occur within the entire potential lagoon-side affect area; however, due to a lack of supporting data, effects to eggs appear to be discountable on both sides of Illeginni Islet at this time.

Scalloped hammerhead sharks (*Sphyrna lewini*) and manta rays (*Manta alfredi* and *M. birostris*) may possibly occur in the vicinity of Illeginni Islet but are unlikely to be in the direct contact affect area. Due to the lack of data and rarity of observations on these species, density estimates for these species were not derived and project-related estimates of affected individuals for these species were not calculated.

For each relevant coral and mollusk consultation species, a bootstrap methodology was used to derive mean density values with a 99% upper confidence limit (UCL) in both ocean and lagoon assessment areas (NMFS-PIRO 2017a and 2017b). These density values are then applied to an estimated area of habitat within the potential affect area (Table 5-13).

When calculating the number of adult coral and mollusks potentially affected by the action, we used the 99% UCLs of the bootstrap mean density values for relevant consultation species at the recommendation of NMFS. However, as noted above, not every consultation fish, coral, and mollusk individual within an affected habitat area would be equally vulnerable to the effects of debris fall and shock wave impacts (NMFS-PIRO 2014a and 2014b). These effects should be assumed to affect only a proportion of the associated coral colonies, mollusks, fish and eggs that may be present, and these are maximal estimates of potential effect. There are no data available to identify this proportion of organism vulnerability within an affected habitat area therefore we present the total, uncorrected number here.

Results. Based on conservative density estimates and the sizes of affected habitat for a worst-case scenario payload shoreline strike, the numbers of adult and juvenile humphead wrasses expected to be present on the lagoon side and ocean side of Illeginni were estimated by NMFS-PIRO 2014b and 2017a). On the lagoon side, an estimated maximum of 100 juvenile humphead wrasses may be found in habitats in both the debris fall and shock wave affect areas. On the ocean side, estimates of the maximum numbers of humphead wrasse in habitat affected by both debris fall and shock waves are eight adults and zero juveniles.

Based on density estimates from a recent survey of the affect area and the sizes of affected habitat for a worst-case scenario payload shoreline strike, the numbers of consultation coral colonies and individual mollusks that may be present were estimated for each species on the lagoon side and ocean side of Illeginni (Table 5-13). On the lagoon side, estimates of the maximum numbers of consultation coral colonies and individual mollusks are 4,725 and 79, respectively, in habitat affected by debris fall. On the ocean side, a maximum of 5,692 consultation coral colonies and 15 individual mollusks are expected to be in the area with the potential to be affected by direct contact from payload impact.

Table 5-13.
Estimated Numbers of Consultation Coral Colonies and Individual Mollusks in Affected Habitats.[1]

	Ocean Side Debris Fall Area				Lagoon Side Debris Fall Area			
Species	**Mean Colonies or Individuals (per m²)**	**99% UCL (per m²)**	**Affected Habitat (m²)**	**# of Colonies or Individuals**	**Mean Colonies or Individuals (per m²)**	**99% UCL (per m²)**	**Affected Habitat (m²)**	**# of Colonies or Individuals**
Corals								
Acropora microclados	0.0004	0.0017	9,756	17				
Acropora polystoma	≤0.0004	0.0017	9,756	17				
Cyphastrea agassizi					0.0003	0.0013	10,406	14
Heliopora coerulea					0.16	0.45	10,406	4,683
Pavona venosa					0.0003	0.0013	10,406	14
Pocillopora meandrina	0.3	0.58	9,756	5,658				
Turbinaria reniformis					≤0.0003	0.0013	10,406	14
Coral Subtotal				**5,692**				**4,725**
Mollusks								
Hippopus hippopus	0.0003	0.0015	9,756	15	0.002	0.006	10,406	63
Tectus niloticus					0.00006	0.0003	10,406	4
Tridacna squamosa					0.0002	0.0011	10,406	12
Mollusk Subtotal				**15**				**79**

[1] The species in this table include those found during a 2004 assessment of the affect areas (NMFS-PIRO 2017a and 2017b). Coral colony and individual mollusk mean densities and 99% UCL provided by NMFS-PIRO (2017a and 2017b).

As discussed earlier, not every consultation species individual or colony within an affected area of habitat would be equally vulnerable to the effects of debris fall and shock wave impacts (US Navy 2017a, NMFS-PIRO 2017c). These effects should be assumed to affect only a proportion of the associated coral colonies, mollusks, and fish that may be present.

It is important to recall that the estimated numbers of colonies or individuals potentially affected are based on a worst-case scenario of a payload land impact. Based on these analyses, a lagoon-side shoreline impact at Illeginni would affect more consultation organisms than an ocean-side shoreline impact. It is anticipated that planned land strikes would not be targeted close to the shoreline and impacts to nearshore consultation species will be avoided. As can be seen in Figure 5-1, the entire potential affected reef area is very small in comparison to the total comparable reef area surrounding and connected to Illeginni Islet. Moreover, this area is considered extremely small compared to sum of comparable reef areas in the USAKA area per the current military use agreement with the RMI, and very small in comparison with comparable reef areas within the entire atoll.

A summary of recorded distributions of these consultation species, based on observations made during USAKA inventories between 2010 and 2016, is shown in Table 4-7. A total of 125 sites were surveyed for protected corals since 2010 including Illeginni Harbor. These 7 species of coral appear to be geographically widespread. Of the 7 coral species that have the potential to be affected by direct contact as adults, all were observed at multiple islets (at least 6 islets) and 5 of these species were observed at all 11 surveyed islets (Table 4-7). With the exception of *Acropora polystoma* (found at only 8% of sites) these species appear to be common throughout Kwajalein Atoll as well. Three species were found at approximately 30% of surveyed sites across the atoll (*Pavona venosa* at 32%, *Turbinaria reniformis* at 30%, and *Cyphastrea agassizi* at 28%) while *Acropora microclados* (82% of sites), *Heliopora coerulea* (61% of sites), and *Pocillopora meandrina* (96% of sites) were very common at Kwajalein Atoll (Table 4-7).

The three consultation mollusk species that are known to occur in the area subject to potential direct contact effects are found throughout Kwajalein Atoll (Table 4-8). *Hippopus hippopus* and *Tectus niloticus* have been observed at all 11 of the surveyed USAKA islets and *Tridacna squamosa* has been observed at 9 of the 11 (Table 4-8). These species are also relatively common, being found at 38% (*Hippopus hippopus*) to 63% (*Tectus niloticus*) of surveyed sites across the atoll since 2010 (Table 4-8).

The scalloped hammerhead shark and manta rays appear to be uncommon at Kwajalein Atoll and around Illeginni Islet. Neither scalloped hammerhead sharks nor reef manta rays have been recorded on biennial surveys of USAKA islets. Oceanic manta rays have occasionally been recorded in surveys of USAKA islets including Illeginni Islet; however, observations are rare. The humphead wrasse is common and widespread in distribution within USAKA. A total of 125 sites across Kwajalein Atoll have been surveyed for protected fish since 2010 (Table 4-6). *Cheilinus undulatus* has been observed at 32 of these sites (26%) and at 10 of the 11 surveyed islets (Table 4-6).

All of the fish, coral, and mollusk species that may be adversely affected by the Action are believed to be relatively prolific, spawning massively at least once a year. New recruits for these species are likely to be very abundant and come from multiple sources within Kwajalein Atoll.

5.1.2.3 Effect Determinations for Direct Contact

Broad Ocean Area. The scalloped hammerhead shark, reef manta ray, adult humphead wrasse, adult corals, adult mollusks, and one cetacean species (Table 4-2) do not or are not likely to occur in the BOA and, therefore, will not be affected by direct contact from vehicle components in the BOA.

Direct contact from spent rocket motors or other FE-2 vehicle components in the BOA would have no effect on cetaceans, the Hawaiian monk seal, Newell's shearwaters, sea turtles, the oceanic giant manta ray, the Pacific bluefin tuna, or two species of sharks. As analyzed in Section 5.1.2.2, the chance of an individual cetacean, monk seal, bigeye thresher shark, or sea turtle being in the area subject to unavoidable injury or death is so low as to be discountable. While no density estimates are available for birds or most fish in the BOA, their densities are likely to be very low and patchy as well.

Direct contact from splashdown of rocket components would also have no effect on larval fish, corals, and mollusks in the BOA. The density of consultation fish, coral, and mollusk larvae in the BOA is unknown but likely extremely low given the great distance the spent motor drop zones are from reproductive areas for these species. As discussed in Section 5.1.2.2, number of fish, coral, and mollusk larvae in the BOA of the Action Area is expected to be extremely small in relation to their total numbers, their distribution, and their life history and effects are considered so unlikely as to be discountable.

Vicinity of Illeginni Islet. At Illeginni Islet, the payload is planned to impact over land. Impacts in most areas of the Illeginni Islet impact zone would not affect marine environments. There is a chance that the payload would impact on or close to the Illeginni Islet shoreline. In this case, ejecta from a crater on land and/or fragments from payload impact may land in nearshore areas. Although attempts will be made to target the payload to avoid these sensitive areas, the worst-case scenario of a shoreline payload impact was analyzed in this BA to evaluate the maximum effects on biological resources.

Most cetacean species (≥14; Table 4-2), Hawaiian monk seals, Newell's shearwaters, 3 sea turtle species (Table 4-4), and 4 fish species (Table 4-5) do not occur in the immediate vicinity of Illeginni Islet and, therefore, will not be adversely affected by direct contact from payload fragments or ejecta in this area.

Cetaceans and scalloped hammerhead sharks will not be affected by direct contact from payload components in the vicinity of Illeginni Islet. All effects from direct contact with payload fragments or ejecta are expected to occur within 91 m (300 ft) of a payload impact. The depth within 91 m (300 ft) of the shoreline is less than 3 m (10 ft). Cetaceans do not occur at these depths, and scalloped hammerhead sharks are not known to occur within 91 m (300 ft) of the Illeginni Islet shoreline.

Manta rays may be affected but are not likely to be adversely affected by direct contact from payload components in the vicinity of Illeginni Islet. While the manta rays are known to occur near Illeginni Islet, observations are rare and the chance of a manta ray being within 91 m (300 ft) of payload impact and being injured by falling debris or ejecta is likely so low as to be discountable.

Green and hawksbill sea turtles may be affected by are not likely to be adversely affected by payload impact on Illeginni Islet. It is unlikely that sea turtles in the water or on land will be within the 91 m (300 ft) radius of an impact on Illeginni Islet. While it is possible that a land strike could adversely affect sea turtle nesting habitat on Illeginni Islet, no evidence of sea turtle nesting has been recorded on Illeginni Islet since 1996. Since no sea turtle nesting activity has been observed on Illeginni in over 20 years, we conclude that the probability of sea turtles nesting in the Action Area is so low as to be discountable. Mitigation measures will also be implemented to detect sea turtles or sea turtle nests in the Action Area prior to the test flight.

Direct contact from payload fragments or ejecta may affect and is likely to adversely affect the humphead wrasse, seven species of consultation coral, and three consultation mollusk species in the event of a shoreline impact (Table 5-13). Estimates of the number of individuals or colonies with the potential to be affected by direct contact are discussed in Section 5.1.2.2. While some consultation organisms are likely to be adversely affected in the event of a shoreline payload impact, a payload impact further inland than 91 m (300 ft) from the shoreline is expected to have no effects from direct contact on these marine species or their habitats. The above discussed estimates assume 100% injury or loss which is likely an overestimate of effect, especially as distance from the point of impact increases. Overall, since there will be only one payload impact and attempts will be made to avoid a shoreline impact, estimates of effect presented in Section 5.1.2.2 should be considered high estimates with a low (but unknown) probability of occurring.

Direct contact from payload debris or ejecta from a shoreline impact may affect individual larval fish, corals, and mollusks of the other consultation species in Tables 4-5, 4-7, and 4-8; however, the effects are considered insignificant or discountable. The Proposed Action may injure or kill a small but undeterminable number of fish, coral, and mollusk larvae. As discussed in Section 5.1.2.2, the effects of the Proposed Action on larval fish, coral, and mollusks are expected to be extremely small in relation to their total numbers, their distribution, and their life history. Direct contact from falling debris or ejecta may affect but is not likely to adversely affect fish, coral, and mollusk larvae.

5.1.3 Vessel Strike

5.1.3.1 Sources of Vessel Strike Stress

The Proposed Action has the potential to increase ocean-going vessel traffic in the Action Area. The Action will result in vessel traffic in the BOA for on-board sensor placement along the flight path (Figure 3-1). A series of sensors would be onboard three vessels: the MATSS, the Range Safety System on board the US Motor Vessel *Pacific Collector*, and the Pacific Tracker. All of these sensors are existing programs and would be scheduled for use based on availability.

Pre-test activities will include vessel traffic to and from Illeginni Islet. Prior to the test flight, radars will be placed on Illeginni Islet and will be transported aboard ocean-going vessels. Sensor rafts will also be deployed near the impact site from a LCU vessel including 12 self-stationing LIDSS rafts, some with hydrophones. Post-test recovery efforts will also result in increased vessel traffic to the payload impact site. There will be several pre-test vessel round-trips to and from Illeginni Islet as well as raft-borne sensor deployment using a LCU. Vessels will be used to transport heavy equipment (such as backhoe or grader) and personnel for manual cleanup of debris, backfilling or any craters, and instrument recovery. Deployed sensor rafts will also be recovered by a LCU vessel. Debris will only be recovered in waters up to approximately 55 m (180 ft) deep. Post-test vessel traffic will likely include several vessel round-trips to and from Illeginni Islet and LCU retrieving raft-borne sensors. Vessel traffic to and from Illeginni Islet will be increased for a period of up to 10 weeks.

Consultation organisms have the potential to be affected by vessel strike primarily by being at the surface when a vessel travels through an area. Organisms at the surface are at risk of being struck by the vessel or their propellers. Organisms that are not found at the sea surface have the potential of being struck when a vessel drops anchor or if a vessel runs aground.

5.1.3.2 Effect Determinations for Vessel Strike

Broad Ocean Area. The scalloped hammerhead shark, reef manta ray, adult humphead wrasse, adult corals, adult mollusks, and one cetacean species (Table 4-2) do not or are not likely to occur in the BOA and, therefore, will not be affected by increased vessel traffic in the BOA.

Increase vessel traffic in the BOA would have no effect on cetaceans, the Hawaiian monk seal, Newell's shearwaters, sea turtles, the giant manta ray, the Pacific bluefin tuna, or two species of sharks for the following reasons:

- A small number of vessel trips will be required in the BOA to position onboard sensors;
- There will be only one test flight;
- While cetaceans, monk seals, and sea turtles breath air, must surface to breathe, and are known to bask at the ocean surface, these are highly mobile animals capable of avoiding vessels and they may already be used to some vessel traffic in the Action Area;
- Consultation fish species do not need to surface to breathe are not known to frequent the ocean surface, and are highly mobile animals capable of avoiding vessels;
- Newell's shearwaters may rest on the ocean surface but are very mobile animals which can fly away from approaching vessels and have even been known to follow vessels to feed on prey in the wake of vessels;
- While the density and distribution of birds and fish in the BOA is largely unknown, consultation organisms are likely to have very low densities (see Section 5.1.1) and patchy distributions in this part of the Action Area; and
- Vessel operators will watch for and avoid marine mammals and sea turtles by adjusting their speed (see Section 3.4, Mitigation Measures).

Increased vessel traffic would have no effect on larval fish, corals, and mollusks in the BOA. The abundance of larval fish, corals, and mollusks of consultation species in the BOA is likely to be extremely low. The density of consultation fish, coral, and mollusk larvae in the BOA is unknown but likely extremely low given the great distance the spent motor drop zones are from reproductive areas for these species. As discussed in Section 5.1.2.2, number of fish, coral, and mollusk larvae in the BOA of the Action Area is expected to be extremely small in relation to their total numbers, their distribution, and their life history and effects are considered so unlikely as to be discountable.

Vicinity of Illeginni Islet. Fourteen consultation cetacean species, Hawaiian monk seals, Newell's shearwaters, three species of sea turtle, and four species of fish do not occur in the vicinity of Illeginni Islet and, therefore, will not be affected by vessel activity in this area.

Cetaceans, sea turtles, and adult fish, corals, and mollusks present in the vicinity of Illeginni Islet may be affected but are not likely to be adversely affected by vessel strike for the following reasons:

- A small number of vessel trips will be required to support pre-flight and post-flight cleanup activities;
- There will be only one flight;
- While cetaceans and sea turtles breath air, must surface to breathe, and are known to bask at the ocean surface, these are highly mobile animals capable of avoiding vessels and they may already be used to some vessel traffic in the Action Area;
- Consultation fish species do not need to surface to breathe, are not known to frequent the ocean surface, and are highly mobile animals capable of avoiding vessels;

- Corals and mollusks have the potential to be struck by a dropped anchor, a vessel, or other equipment contacting reef habitats, although this is unlikely, vessel operators will be made aware of sensitive reef habitats in order to avoid these areas;
- Vessel operators will watch for and avoid cetaceans and sea turtles by adjusting their speed (see Section 3.4, Mitigation Measures); and
- LIDSS rafts will be deployed in waters at least 4 m (13 ft) deep to avoid hydrophone contact with the substrate and/or coral colonies.

Larval fish, coral, and mollusks may be and are likely to be adversely affected by increased vessel traffic in the vicinity of Illeginni Islet. Larval densities are generally higher nearer to the reef and decrease as distance increases. These larval densities depend on conditions including ocean currents and seasonality. Since the eggs, sperm, and larval stages of these organisms may be in the water column for extended periods of time, it is likely that at least some larval fish, coral, and/or mollusks may be in areas where vessels will pass through. Cavitation from vessels traveling through an area could lead to decreased fertilization, larval deformities, or even larval death (NMFS 2015b). Studies have provided evidence that larvae subject to highly turbulent water may die or have abnormal development (NMFS 2015b). It is likely that a low but unknowable number of fish, coral, or mollusk larvae will be affected by cavitation from vessels traversing the area. In general, the consequences of taking individual larvae are considered to be substantially less severe than the consequences of taking individual adults because the baseline mortality rate of larvae is several orders of magnitude higher than for adults; therefore, the odds of individual larvae surviving to reproductive age are substantially lower than the odds of an adult surviving to reproduce again (Gascoigne and Lipcius 2004). Population effects to consultation species are discountable for this reason; because the affected area is trivially small relative to the distribution of these invertebrates; and because the number of larvae potentially affected is likely to be trivially small relative to their population sizes and the effects are considered discountable.

5.1.4 Exposure to Hazardous Chemicals

The Proposed Action has the potential to introduce hazardous chemicals into the Action Area. Splash-down of vehicle and payload components has the potential to introduce propellants, hydraulic fluids, battery acids, explosives, and heavy metals into the marine environment of the BOA. Land impact of the payload would have the potential to introduce propellants, battery acids, explosives, and heavy metals into the terrestrial environment of Illeginni Islet. Pre-test preparatory and post-test cleanup activities may involve heavy equipment and ocean-going vessels, which have the potential to introduce fuels, hydraulic fluids, and battery acids to terrestrial habitats as well as marine habitats. Any accidental spills from support equipment operations would be contained and cleaned up. All waste materials would be transported to Kwajalein Islet for proper disposal. A small number of small radars are considered expendable and may be destroyed during testing. While the debris from these radars is expected to be recovered, battery acids and heavy metals may be introduced into the terrestrial environment and may potentially leech into the marine environment.

5.1.4.1 Sources of Hazardous Chemicals

Broad Ocean Area. Any substances of which the launch vehicle is constructed or that are contained on the launch vehicle and are not consumed during FE-2 flight or spent motor jettison (Table 3-1) will fall into the BOA when first-, second-, and third-stage launch vehicle motors and nose fairing are released. The launch vehicle includes rocket motors, rocket propellant, magnesium thorium in the booster interstage, asbestos in the second stage, battery electrolytes (lithium-ion and silver-zinc), radio frequency transmitters, and small electro-explosive devices (Table 3-1). Though the batteries carried onboard the rocket motors would be discharged by the time they splash down in the ocean, they would still contain small quantities of electrolyte material. These materials, along with residual amounts of propellant, asbestos, and heavy metals contained in the first- and third-stage motors or nose fairing, may contaminate seawater. The release of such contaminants could harm a consultation organism that comes in contact with, or ingests, toxic levels of these solutions.

In an evaluation of the effects of rocket systems that are deposited in seawater, the National Aeronautics and Space Administration concluded that the release of hazardous materials carried onboard launch vehicles would not significantly impact marine life. Materials would be rapidly diluted in the seawater and, except for the immediate vicinity of the debris, would not be found at concentrations that produce adverse effects (US Navy 1998).

Overall, larger and heavier vehicle components will sink fairly quickly to the ocean floor. Ocean floor depths in the BOA are so deep that consultation organisms are not likely to be in contact with these materials. Any chemicals that do leak into the water column will be quickly diluted by ocean currents and the very large volume of ocean water.

Vicinity of Illeginni Islet. The payload would impact over Illeginni Islet. Following the impact of the payload, fragmentation of the payload would disperse any of the residual onboard hazardous materials (Table 3-2) such as battery acids, residual explosives, and heavy metals, around the impact point. Onboard the payload there will be up to three lithium ion batteries each weighing between 1 to 23 kg (3 and 50 lb) and two radio frequency transmitters. The batteries carried onboard the payload would be discharged by the time the vehicle impacts on land at Illeginni Islet; however, a small quantity of electrolyte material (on the order of a couple ounces) may still enter the terrestrial environment. The payload also carries up to 454 kg (1,000 lb) of tungsten alloy which will enter the terrestrial and possible marine environments upon payload impact. The payload structure itself contains heavy metals including aluminum, titanium, steel, magnesium, tungsten, and metal alloys.

With the payload impact on Illeginni Islet, debris including hazardous materials would fall on Illeginni Islet and possibly into nearshore habitats. Debris and ejecta from a land impact would be expected to fall within 91 m (300 ft) of the impact point. Post-flight cleanup of the impact area will include recovery/ cleanup of all visible debris including during crater backfill. Searches for debris would be attempted out to water depths of 55 m (180 ft) if debris enters the marine environment. Considering the small quantities of hazardous materials contained in the batteries, the planned land impact, and the dilution and mixing capabilities of the ocean and lagoon waters, the battery materials released during payload impact should be of little consequence to any cetaceans, fish, or sea turtles in the area. Any visible battery fragments in the lagoon, in other shallow waters, or on Illeginni Islet would be removed during recovery and cleanup. While every attempt will be made to clean up all visible metal and other fragments, it is possible and likely that some fragments will be too small to be recovered or may be buried by the force of impact. Therefore, it should be considered that a small but unknowable amount of these heavy metals or other substances may remain in the terrestrial or marine environments at Illeginni Islet.

Since up to 454 kg (1,000 lb) of tungsten alloy will be contained on the payload and be introduced into the terrestrial (and possibly marine) environments upon payload impact, it is possible that a small but unknown amount of tungsten alloy will remain at Illeginni Islet. While the effects of tungsten alloys in ecosystems is largely unknown, recent studies have concluded that under certain environmental conditions tungsten may dissolve and some forms of tungsten (depending on soil conditions) can move through soil (Dermatas et al. 2004). In the presence of alloying elements such as iron, nickel, and cobalt, tungsten was sorbed to clay soils and mobility was decreased; however, this sorption also depends on soil conditions such as pH and mineral and organic composition (Dermatas et al. 2004). Soils on Illeginni Islet are primarily well-drained and composed of calcareous sand poor in organic materials with a few carbonate fragments. Some studies suggest that introduction of tungsten into soil increases soil pH and may impact soil microbial communities (Dermatas et al. 2004, Strigul et al 2005). There is also some evidence that soluble tungsten may decrease biomass production, and that plants and worms may take up tungsten ions from the soil (Strigul et al. 2005). While the effects of tungsten remaining in the soil at Illeginni Islet are largely unknown, the impact area is largely a disturbed area where there would not likely be significant environmental effects.

As a mitigation measure for the FE-1 test flight, the US Navy and USASMDC completed a bench study to measure the dissolution and migration of the tungsten alloy in Illeginni Islet soils (Appendix D in US Navy 2017b) and collected soil samples at Illeginni before and after the flight test. These studies indicate that tungsten concentrations in the water and soils near test locations at Illeginni may increase as rainfall begins the dissolution process. The average level of tungsten in the soil prior to the FE-1 test was 1.3 milligram (mg)/kg (range of 0.2 to 8.5 mg/kg) and the average level following the test was 3.0 mg/kg (range of 0.7 to 9.0 mg/kg). Some preliminary computer modeling developed for the FE-1 flight test estimated an average concentration of tungsten in the soil to be 6.5 mg/kg. While concentrations may remain elevated for several years, post test tungsten concentrations in soil samples from Illeginni were below the US Environmental Protection Agency (EPA) screening levels for soils in residential (63 mg/kg) and industrial (930 mg/kg) areas (US Navy 2017b, Zavarin et al. 2018).

Water samples collected from an impact crater on Illeginni after the FE-1 test had elevated tungsten concentrations (0.65 mg/liter [L]) which were above the US EPA's screening level for residential tapwater (0.016 mg/L; Zavarin et al. 2018). Predictions resulting from an early reactive transport model were that tungsten concentrations in groundwater would fall at or below the US EPA screening level of 0.016 mg/L. However, in the model, this predicted concentration was strongly dependent on the spatial distribution of tungsten, the surface area of the tungsten, and the estimated annual precipitation on the island. It would be expected that tungsten concentration in subsurface waters may be higher than the EPA screening level under certain event conditions. However, the presence and extent of a subsurface freshwater lens at Illeginni Islet is unknown and it is not known whether the presence of tungsten would have any adverse effects on biological resources there. The high concentrations observed in the crater bottom shortly after the FE-1 test may reflect the dissolution of high surface area particulate tungsten in a limited area.

Tungsten concentrations at Illeginni Islet over time were also estimated using a model which incorporated the results of the column experiments measuring dissolution and sorption of tungsten in Illeginni Islet soils (US Navy 2017b). The calibrated dissolution rate and sorption affinity were then used in a simple one-dimensional model of the area of tungsten deposition to estimate tungsten concentrations in the freshwater zone just below the zone of tungsten deposition in soil. Shortly after tungsten is deposited in the carbonate soil and rainfall begins the dissolution process, aqueous tungsten concentrations would increase. With regular precipitation (assumed at 2.5 m/yr) modeled concentrations reached a steady state in less than one year and remained constant for the following 25 years, the period for which the model was run. The steady state concentration was primarily controlled by the rate of tungsten alloy dissolution and the rate of precipitation. Based on the model parameters, estimated aqueous tungsten concentrations will be between 0.006 mg/L (at a dissolution rate of 1.0 mg/m^2/hour) and 0.015 mg/L (at a dissolution rate of 2.6 $mg/m^2/hour$). These results both fall below the US EPA Residential screening level of 0.016 mg/L.

Up to four small radars powered by generators are considered expendable and may be destroyed by the impact. While the debris from these radars is expected to be recovered, acids and heavy metals may be introduced into the terrestrial environment. Only trace amounts of hazardous chemicals are expected to remain in terrestrial areas. If any hazardous chemicals enter the marine environment, they are expected to dilute and dispersed quickly by currents and wave action.

Post-flight cleanup activities may include the use of heavy equipment such as a backhoe or grader on Illeginni Islet. This equipment has the potential to introduce fuels, hydraulic fluids, and battery acids into terrestrial habitats. Equipment operation would not involve any intentional discharges of fuel, toxic wastes, or plastics and other solid wastes that could harm terrestrial or marine life. Any accidental spills from support equipment operations would be contained and cleaned up. All waste materials would be transported to Kwajalein Islet for proper disposal. Hazardous materials would be handled in adherence to the hazardous materials and waste management systems of USAG-KA. Hazardous waste incidents would comply with the emergency procedures set out in the KEEP and the UES. Following cleanup and repair operations at Illeginni Islet, soil samples will be collected at various locations around the impact area and tested for pertinent contaminants.

Several mitigation measures will be employed to reduce the potential effects of hazardous chemicals including:

- Vessel and equipment operations would not involve any intentional discharges of fuel, toxic wastes, or plastics and other solid wastes that could harm terrestrial or marine life.
- Hazardous materials would be handled in adherence to the hazardous materials and waste management systems of USAG-KA. Hazardous waste incidents would comply with the emergency procedures set out in the KEEP and the UES.
- Vessel and heavy equipment operators would inspect and clean equipment for fuel or fluid leaks prior to use or transport and would not intentionally discharge fuels or waste materials into terrestrial or marine environments.
- Debris recovery and site cleanup would be performed for land or shallow water impacts. To minimize long-term risks to marine life, all visible project-related debris would be recovered during post-flight operations, including debris in shallow lagoon or ocean waters by range divers. In all cases, recovery and cleanup would be conducted in a manner to minimize further impacts on biological resources.

5.1.4.2 Effect Determinations for Hazardous Chemical Exposure

Broad Ocean Area. The scalloped hammerhead shark, reef manta ray, adult humphead wrasse, adult corals, adult mollusks, and one cetacean species (Table 4-2) do not or are not likely to occur in the BOA and, therefore, will not be affected by any hazardous chemicals in the BOA.

Chemical release in the BOA would have no effect on consultation species for the following reasons:

- The area affected by the dissolution of chemicals would be relatively small because of the size of the rocket components and the minimal amount of residual materials they contain;
- Components would sink to the ocean bottom, where depths in the BOA reach thousands of feet and most marine mammals, sea turtles, seabirds, and fish are not likely to occur;
- Any chemicals introduced to the water column would be quickly diluted and dispersed; and

- The low density and patchy distribution of marine mammals, sea turtles, shearwaters, fish, and larval fish, corals and mollusks in the BOA further decrease the likelihood of contact with hazardous chemicals.

Vicinity of Illeginni Islet. Most cetacean species (≥14; Table 4-2), Hawaiian monk seals, Newell's shearwaters, 3 sea turtle species (Table 4-4), and 4 fish species (Table 4-5) do not occur in the immediate vicinity of Illeginni Islet and, therefore, will not be adversely affected by hazardous chemicals in this area.

Cetaceans and scalloped hammerhead sharks will not be affected by hazardous chemicals from payload components in the vicinity of Illeginni Islet. All effects from hazardous chemicals are expected to occur within 91 m (300 ft) of a payload impact or on Illeginni Islet. The depth within 91 m (300 ft) of the shoreline is less than 3 m (10 ft). Cetaceans do not occur at these depths and scalloped hammerhead sharks are not known to occur within 91 m (300 ft) of the Illeginni shoreline.

Chemicals dispersed at Illeginni Islet may affect but are not likely to adversely affect fish, corals, or mollusks because:

- Most payload fragments and chemicals should be contained within terrestrial environments;
- All visible debris in terrestrial and shallow water (up to water depths of 15 to 30.5 m [49 to 100 ft]) will be recovered; and
- Any soluble chemicals introduced into the marine environment are expected to be quickly dispersed and diluted by ocean currents and wave action.

Hazardous chemicals may affect but are not likely to adversely affect nesting sea turtles or sea turtle nests. As discussed in Section 5.1.2.2 (Estimation of Direct Contact Effects), debris and ejecta from payload impact has the potential to impact suitable sea turtle nesting habitat at Illeginni Islet. This debris and ejecta has the potential to include hazardous chemicals including heavy metals. If these chemicals were introduced into sea turtle nesting habitat, they have the potential to dissuade females from nesting, harm sea turtle eggs, or affect the health of sea turtle hatchlings. Even though post-test cleanup will be conducted, there is a chance that fragments or residual chemicals may remain in suitable sea turtle nesting habitat. While it is possible that a land strike could adversely affect sea turtle nesting habitat on Illeginni Islet, no evidence of sea turtle nesting has been recorded on Illeginni Islet since 1996. Since no sea turtle nesting activity has been observed on Illeginni in over 20 years, we conclude that the probability of sea turtles nesting in the Action Area is so low as to be discountable. Mitigation measures will also be implemented to detect sea turtles or sea turtle nests in the Action Area prior to the test flight.

5.1.5 Disturbance from Human Activities and Equipment Operation

Both pre-flight preparations and post-flight cleanup activities will result in elevated levels of human activity in terrestrial and marine environments. Elevated levels of human activity are expected for approximately 10 weeks at Illeginni Islet. Personnel and equipment will be used for preparation of the impact site including placement of radars and other sensors in both terrestrial and marine areas. Post-flight cleanup will involve recovery of all debris possible and will include personnel and equipment in both terrestrial and marine areas. Radars will be retrieved from marine and terrestrial locations and impact craters (if present) will be filled. These activities may include use of heavy equipment such as a backhoe or grader.

5.1.5.1 Sources of Disturbance from Human Activities and Equipment Operation

Almost all pre-flight and post-flight activities will take place in the waters near Kwajalein Atoll and on Illeginni Islet. The only disturbance from human activities in the BOA involves vessel traffic as analyzed in Section 5.1.3. Elevated levels of human activity are expected for approximately 10 weeks at Illeginni Islet. During this period, several vessel round-trips are likely. Helicopters will also be used to transport equipment and personnel to Illeginni Islet. The Action is expected to involve as many as two dozen personnel on Illeginni during the 10-week period. Activities associated with pre- and post-flight operations near the Illeginni shoreline, which could affect sea turtles, fish, corals, or mollusks, include noise, physical contact, turbidity changes, or habitat disturbance. In the event of an impact on the Illeginni shoreline, post-flight operations would be conducted similarly to terrestrial operations, when tide conditions and water depth on the adjacent nearshore reef permit. A backhoe would be used to excavate the crater, excavated material would be screened for debris, and the crater would usually be backfilled with substrate that had been ejected around the wall of the crater. Should any components or debris impact areas of sensitive biological resources such as the coral reef, USFWS or NMFS would be contacted to provide guidance and/or assistance in recovery operations to minimize impacts to resources (see Section 3.4, Mitigation Measures).

Acoustic effects associated with post-test operations would be consistent with any other land or sea activity that uses mechanized equipment, and the greatest intensity would be centered on the payload impact location. Potential consequences of these acoustic effects include noise avoidance and temporary disruption of feeding or predator avoidance behaviors in sea turtles, some motile invertebrates, and small fish (Mooney et al. 2010). Because these acoustic effects are substantially less intense than sonic boom overpressures, the area of potential effect would be substantially smaller (See Section 5.1.1.3) and restricted to relatively poor reef habitats near the shoreline.

In the event that recovery operations must take place in the shallow water marine environments at Illeginni Islet, physical contact by humans (e.g., handling, walking on, and kicking with fins) is likely to injure corals and likely to disturb reef-associated fish and mollusks. Contact by equipment is also likely to injure or kill corals and mollusks and may injure or kill reef-associated fish. As mentioned earlier, an organism's potential to recover from injury is a function of intrinsic and extrinsic factors. The extent of this potential impact will be restricted to the vicinity of the payload land impact site and the access corridor between this site and the adjacent reef.

If divers are required to search for payload debris on the adjacent reef flat, they would be briefed prior to operations about coral fragility and provided guidance on how to carefully retrieve the very small pieces of payload debris that they would be looking for. Although diver recovery operations might cause minor coral colony breakage, it is unlikely that any entire colonies would be killed. Although top shell snails and giant clams may be moved out of the way, it is unlikely that these mollusks would be killed due to the strong and protective nature of mollusk shells. Sea turtles, humphead wrasses, and manta rays, which are normally patchy in distribution and usually present as solitary individuals or in very low numbers, might be present. However, due to their natural wariness, they are expected to shy well away from the divers and not be killed or injured.

Post-flight activities have the potential to increase turbidity in the marine environment by mobilizing small particles. Increased turbidity has the potential to affect marine consultation organisms, especially filter-feeding invertebrates such as the consultation species of corals and mollusks. Potential consequences include decreased feeding efficiency and increased effort expended to clear sediments (Cortes and Risk 1985; Rogers 1990). However, increased turbidity associated with the operations would be temporary, and turbidity would likely return to background levels within a few hours of the activity's conclusion.

Marine organisms such as cetaceans, sea turtles, sharks, and manta rays may be disturbed by vessel traffic for delivering personnel and equipment, dive operations for debris recovery, and by deployment of radar rafts. These highly mobile animals may exhibit avoidance behavior by leaving the disturbed area. However, animals are expected to return to normal distributions and behaviors soon after the disturbance has ceased, and effects are expected to be insignificant.

In shallow waters near Illeginni Islet, some species of consultation corals, mollusks, and the humphead wrasse have the potential to be disturbed by shallow water debris recovery and/or backfill operations (see Section 5.1.2.2 for occurrence and density data). Humphead wrasses are highly mobile animals and may exhibit avoidance behavior, temporarily leaving the site of increased human activity. There is no reason to expect that these fish would not return to these areas once the disturbance has ended. Mollusks are immobile and cannot flee from human activity, but they may respond to disturbance by closing their shells which would decrease their foraging activity. It is expected that mollusks would resume normal behaviors shortly after cessation of the disturbance activity. Corals may be affected by disturbance from debris recovery and/or backfill operations. However, personnel will be advised to avoid or uses extreme caution if debris is located near corals and reef habitats to avoid damage to these consultation organisms. Divers would be briefed prior to operations about coral fragility and provided guidance on how to avoid or minimize unavoidable contact with fragile marine resources as they carefully retrieve the small pieces of debris that may be introduced in the marine environment. In the event that payload debris or ejecta impacts reef habitats, there is a chance that recovery operations might cause minor coral colony breakage and therefore a small but unknown number of coral colonies may be affected. This is not expected to be greater than or in addition to the estimates of effect for direct contact analyzed in Section 5.1.2.2.

5.1.5.2 Effect Determinations for Disturbance from Human Activities and Equipment Operation

Broad Ocean Area. The scalloped hammerhead shark, reef manta ray, adult humphead wrasse, adult corals, adult mollusks, and one cetacean species (Table 4-2) do not or are not likely to occur in the BOA and, therefore, will not be affected by any disturbance from human activity and equipment in the BOA.

Disturbance from human activity and equipment operation would have no effect on marine mammals, birds, sea turtles, adult fish, or larval fish, coral, or mollusks in the BOA. The duration of disturbance is expected to be short, and these widely dispersed, highly mobile species are able to avoid areas of disturbance by leaving the area. It is expected that these species would return to normal behaviors and distributions after cessation of human activities or equipment operation and that the animals' natural behavioral patterns would not be significantly altered.

Vicinity of Illeginni Islet. Most cetacean species (≥14; Table 4-2), the Hawaiian monk seal, Newell's shearwater, 3 sea turtle species (Table 4-4), and 4 fish species (Table 4-5) do not occur in the immediate vicinity of Illeginni Islet and, therefore, will not be adversely affected by disturbance from human activity or equipment operation on or near Illeginni Islet.

Disturbance from human activity and equipment operation may affect but is not likely to adversely affect cetaceans, sea turtles, scalloped hammerhead sharks, manta rays, or larval corals and mollusks in the vicinity of Illeginni Islet for the following reasons:

- The duration of the disturbance is expected to be short;
- Cetaceans, sea turtles, and fish are highly mobile species, able to avoid areas of disturbance by leaving the area, and it is expected that these species would return to normal behaviors and distributions after cessation of human activities or equipment operation. Disturbance from human activity is not expected to significantly alter the natural behavioral patterns of these organisms; and
- While it is possible that post-test cleanup and recovery operations could adversely affect suitable sea turtle nesting habitat on Illeginni Islet, no evidence of sea turtle nesting has been recorded on Illeginni Islet since 1996. Since no sea turtle nesting activity has been observed on Illeginni Islet in over 20 years, we conclude that the probability of sea turtle nesting in the Action Area is so low as to be discountable.

Disturbance from human activity and equipment operation may affect and is likely to adversely affect consultation corals (seven species), mollusks (three species), and humphead wrasses. In the event that payload debris or ejecta enters the marine environment, post-flight cleanup activities may affect coral colonies or individual mollusks. While mitigation measures will be employed (see Section 3.4: Mitigation Measures) and a shoreline strike is not planned or expected, if there are effects, these effects are expected to be adverse because:

- Recovery and cleanup activities would include contact with the seafloor, and this is likely to disturb, injure, or kill marine invertebrates. Mitigation measures will minimize this impact, but some contact is unavoidable. The extent of seafloor contacted is a function of location, depth, tools and techniques employed for cleanup, and the degree to which mitigation measures can be implemented; and
- Turbidity would temporarily increase causing temporary alterations in organism's behavior. The duration of turbidity increase is a function of location, depth, and the tools and techniques employed for cleanup. Turbidity and organism's behavior would likely return to their background states within a few hours of the activity's conclusion and significant, lasting effects are unlikely.

5.2 Newell's Shearwaters at PMRF/KTF

The environmental effects of STARS launch activities at PMRF have been previously analyzed in the *HRC EIS/OEIS* (US Navy 2008), and a Programmatic BO for PMRF, including launch activities at KTF, was issued in 2014. While this programmatic BO included Newell's shearwaters, consultation was reinitiated for this species, and PMRF is currently in consultation with USFWS for this species for base-wide activities at PMRF. Therefore, we include a description of the stressors for this species at PMRF, an analysis of the effects of these stressors, and an effect determination for this species.

For FE-2, the STARS launch vehicle will launch from Pad 42 at KTF in PMRF. In 2011, USASMDC/ARSTRAT conducted a similar test using the same launch vehicle from Pad 42 during the Newell's shearwater fledging season. The USFWS issued a BO for that launch. The launch pad was lit using the green lighting system for more than a week prior to the night launch, and there were no Newell's shearwater fall-out events at the launch pad.

With regard to Newell's shearwaters, stressors resulting from the FE-2 Proposed Action are primarily artificial lighting. Artificial lighting can cause fallout of Newell's shearwaters resulting in injury or death. Fallout occurs when fledgling seabirds making their first flights to the ocean from their natal colony are disoriented by artificial light sources and/or strike artificial structures. Although new lights on Kauai are shielded, there is still significant mortality of fledged shearwaters (2–10% or more or fledglings) due to fallout (USFWS 2011b). PMRF implemented a "Dark Skies" program on September 15, 2016. To prevent shearwater fallout, PMRF turns off all non-essential lighting during the shearwater fledgling season, September 15 to December 15.

The Proposed Action will involve pre-launch and launch activities at or near Pad 42 at KTF. Pre-launch activities at KTF include final vehicle and experiment assembly, preflight checks, and demonstration of system performance. These pre-launch activities will not take place at night. The launch will take place within in a 6-hour time period during the first half of fiscal year 2020 (October 2019 to March 2020). The Pad 42 lights will not be turned on for any program activities during the Newell's shearwater period of concern (i.e., 10 days prior to the new moon through 8 days after) during the fledgling season. If program activities are required to occur at night during the period of concern and if for safety reasons pad lights are required, the program will coordinate these activities through PMRF to comply with the Dark Skies policy.

Based on the above policies and mitigation measures, the Proposed FE-2 Action may affect but is not likely to adversely affect Newell's shearwaters at KTF.

6.0 CUMULATIVE EFFECTS

Cumulative Effects include the effects of future state, tribal, local, or private actions that are reasonably certain to occur in the Action Area. Future federal actions that are unrelated to the Proposed Action are not considered in the cumulative effects section of BAs as they require their own separate consultation pursuant to Section 7 of the ESA. Therefore, this analysis of cumulative effects considers the effects of the FE-2 flight test program and the activities and considerations in Table 6-1.

Table 6-1.
Future Actions and Other Environmental Considerations Identified for Cumulative Effects Analysis.

#	Future Action or Consideration	Location in Action Area
1	Commercial and Recreational Fishing	BOA and Kwajalein Atoll
2	Subsistence and Artisanal Fishing	Kwajalein Atoll
3	Vessel Traffic	BOA and Kwajalein Atoll
4	Ocean Pollution	BOA and Kwajalein Atoll
5	Climate Change and Ocean Acidification	BOA and Kwajalein Atoll

This section examines the foreseeable future actions and environmental considerations in the Action Area, evaluates the cumulative effects of these considerations along with the proposed FE-2 test flight on consultation species, and discusses the cumulative effects of rocket launches (including FE-2) on climate change.

6.1 Foreseeable Future Actions and Environmental Considerations

6.1.1 Commercial and Recreational Fishing

Commercial and recreational fishing is prevalent throughout the Pacific including the ocean waters of the Action Area. Fishing can adversely affect not only fish but an abundance of other organisms through overfishing, bycatch, entanglement, and habitat destruction (US Navy 2015b). While commercial and recreational fishing are economically important across the globe, the impacts of fishing have been and continue to be significant. Overfishing of targeted species has been documented as a primary cause of population declines in many at-risk species (see Section 4.0). Overfishing can deplete spawning stocks, thereby reducing a population's ability to replenish itself (NOAA 1998). Commercial and recreational fishing also impact non-target species through bycatch. Bycatch is the capture of non-target organisms such as fish, invertebrates, marine mammals, sea turtles, and sea birds due to the limited selectivity of fishing equipment (NOAA 1998). Bycatch has been cited as a significant factor in population declines of many species protected under the ESA and MMPA (see Section 4.0). Lost fishing equipment can also threaten marine organisms when individuals become entangled in or ingest such debris (NOAA 1998). While little data exists on the effects of lost fishing equipment, entanglement and ingestion of debris have been reported for over 250 marine species (NOAA 1998).

Commercial and recreational fishing can also modify ocean habitats and community dynamics within marine ecosystems. Fishing has the potential to change community structure and food chains by removing predator species, by removing prey species, or by introducing discarded waste or bycatch and thereby changing food availability for other species (NOAA 1998). Fishing can also physically alter marine habitats when fishing gear, propellers, and anchors contact the seafloor, especially in shallow areas (NOAA 1998). Fishing techniques such as bottom trawls and dredges involve equipment being towed along the bottom to capture groundfish, shrimp, and mollusks and can damage shallow-water habitats such as seagrass beds and coral reefs (NOAA 1998).

In the RMI, marine fisheries have two distinct areas, offshore and coastal (FAO 2009). Coastal fishing is primarily for subsistence purposes and for sale in local and export markets (discussed below). Offshore fisheries consist of commercial longlining, purse seining, and pole-and-line fishing and are focused on tuna (FAO 2009). The annual catch from locally-based offshore commercial fisheries in the years leading up to 2009 ranged from 44,000 to 88,000 metric tons with 90% of the catch consisting of tuna (FAO 2009). Foreign-based offshore commercial fishing resulted in 12,700 metric tons of tuna and bycatch in the Marshall Islands Zone in 2007 (FAO 2009). The two most important non-food fisheries in the RMI are for aquarium fish (mostly from Majuro lagoon) and the top shell snail (FAO 2009). A national fisheries policy was approved by the government of the RMI in 1977 to increase fisheries within sustainable limits and to strengthen the capability of the nation to manage its fisheries resources (FAO 2009), and the Marshall Islands Marine Resources Authority (MIMRA) was established under the MIMRA Act in 1988 to manage marine resources and their sustainable development. The Marshall Islands is a member of the Forum Fisheries Agency, a regional arrangement assisting its member countries in managing and conserving the regional tuna stock (RMI Embassy to the US 2005). The RMI is also Party to the Nauru Agreement (PNA) as one of eight member-nations (MIMRA 2017). Since 2010, the PNA has resulted in regional management and conservation measures that relate to the oceanic tuna fishery (MIMRA 2017). According to MIMRA, less than 2% of the total skipjack tuna catch in PNA waters was caught in the Marshall Islands EEZ (MIMRA 2017).

6.1.2 Subsistence and Artisanal Fishing

Subsistence and artisanal fishing are very important in the RMI, especially in the outer atolls and more remote islets where it provides residents with their primary source of animal protein (FAO 2009). Citizens of the RMI use diverse fishing methods including spearing, hand-lining, trolling, gill-netting, and cast netting (FAO 2009). Some subsistence fishing is conducted via paddling or sailing canoes, while most artisanal fishing is conducted from small craft (4.5 to 6 m [15 to 20 ft]) with outboard motors (FAO 2009). Almost all artisanal catches in the RMI are marketed locally and the Food and Agriculture Organization of the United Nations (FAO) estimated 2,800 metric tons produced by costal subsistence fisheries in the Marshall Islands in 2007 (FAO 2009). Although imported food has gained importance in the RMI since the 1960's, the consumption of fish remains substantial and critically important to the outer islands (FAO 2009). MIMRA manages marine resources and their sustainable development in the RMI under a national fisheries policy and the MIMRA Act.

6.1.3 Vessel Traffic

Vessel traffic may impact biological resources by vessels striking marine mammals and sea turtles, introduction of non-native species, emissions, and creation of underwater noise (US Navy 2015b). Although maritime traffic can be very heavy in some offshore areas, 85% of global ship traffic occurs north of the equator and two-thirds of global ship traffic occurs within 370 km (200 nm) of shore (Wang and Corbett 2014). No major maritime shipping routes transect the BOA portion of the Action Area; however, a recent report (Johnson 2016) indicated that over a third of the total skipjack tuna catch (0.6 of the 1.7 million tons) from commercial fisheries in PNA waters was offloaded and shipped from the Port of Majuro. The RMI Port Authority reported 112 vessel calls at the Port of Majuro in 2013 and forecasts that annual cargo volumes to this port will likely double from 2013 levels by 2033 (RMIPA 2014). This is a good indication of shipping conditions in the central Pacific. In Kwajalein Atoll, the majority of vessel traffic is local vessel traffic, such as recreational sailing, diving and fishing boats, and patrol boats. Ferries and personal transport taxis are used to transport RMI citizens and USAG-KA or RTS employees between islets within Kwajalein Atoll. Larger supply container ships transport materials and supplies to USAKA about every two weeks, and fuel barges are also in the area periodically.

6.1.4 Ocean Pollution

Ocean pollution is the introduction of non-normal and harmful contaminants into the marine ecosystem (US Navy 2015b). Ocean pollution has and will continue to have serious impacts on marine organisms and marine ecosystems (US Navy 2015b). Common ocean pollutants include toxic compounds such as metals, pesticides, and other organic chemicals; excess nutrients from fertilizers and sewage; detergents; oil; plastics; and other solids (US Navy 2015b). Pollutants enter oceans from non-point sources (i.e., storm water runoff from watersheds), point sources (i.e., wastewater treatment plant discharges), other land-based sources (i.e., windblown debris), spills, dumping, vessels, and atmospheric deposition (US Navy 2015b).

One of the main ocean pollution concerns in the BOA and waters of Kwajalein Atoll is marine debris, which includes any anthropogenic object intentionally or unintentionally discarded, disposed of, or abandoned in the marine environment (US Navy 2015b). Common types of marine debris include various forms of plastic and abandoned fishing gear, as well as clothing, metal, glass, and other debris (US Navy 2015b). Marine debris degrades marine habitat quality and poses ingestion and entanglement risks to marine life and birds (US Navy 2015b).

Plastic marine debris is a major concern because it degrades slowly and many plastics float, allowing the debris to be transported by currents throughout the oceans (US Navy 2015b). In the North Pacific, currents create subtropical gyres which act to accumulate floating plastic marine debris including an eastern and a western “Garbage Patch” (NOAA 2013). These large debris accumulation areas are not found in the central Pacific due to the equatorial currents and countercurrent, although marine debris is still carried in these currents. South of the equator, much less is known about debris accumulation; however, marine debris carried in the south equatorial current may distribute debris in the Action Area near Kwajalein Atoll. Fish, marine mammals, and birds can mistakenly consume these wastes containing elevated levels of toxins instead of their prey (US Navy 2015b). Debris that sinks to the seafloor is also a concern for ingestion and entanglement by fish, invertebrates, sea turtles, marine mammals, and marine vegetation and may contribute to marine habitat degradation (US Navy 2015b). While the density of marine debris is likely low in the BOA portion of the Action Area, any current debris or future increases in debris have the potential to adversely affect marine organisms and ecosystems.

6.1.5 Climate Change and Ocean Acidification

Ocean ecosystems and marine resources are already being affected by climate change and the related issue of ocean acidification (Griffis and Howard 2013). These effects are expected to increase in coming years (Griffis and Howard 2013). Global sea level has been rising over the past century and the rate has increased in the most recent decades with 2014 global sea levels 6.6 cm (2.6 in) above the 1993 average (Lindsey 2016). Sea levels will likely rise for many centuries to come with rates even higher than current rates (Lindsey 2016). Increasing levels of atmospheric carbon dioxide (CO_2) is one of the most serious problems affecting physical, chemical, and biological properties of oceans (Griffis and Howard 2013). The present atmospheric CO_2 concentrations are higher than they have been at any time in the past 400,000 years (Lindsey 2016). The two primary direct consequences of increased atmospheric CO_2 in marine ecosystems are increased ocean temperatures and higher acidity (Griffis and Howard 2013).

Increasing ocean temperatures have the potential to affect marine organisms and ecosystems in several ways. In addition to the physical change of temperature, ocean temperature change can lead to changes in ice volume, sea level, ocean circulation, available oxygen, and salinity (Griffis and Howard 2013). Research has shown that average temperature of the upper 700 m (2,297 ft) of ocean water has increased by 0.2°C between 1961 and 2003, arctic sea ice volume has shrunk by 75% over a decade, and incidences of hypoxia have increased during the last half century (Griffis and Howard 2013). Air temperature and ocean surface temperatures are strongly correlated as atmospheric heat is absorbed by ocean waters (Griffis and Howard 2013). Data has shown that as atmospheric CO_2 and other greenhouse gas concentrations have increased, air temperatures have increased and so have ocean temperatures (Griffis and Howard 2013). Oceans of the world now have some of the highest temperatures on record (Griffis and Howard 2013). It has been predicted that air temperatures will increase over the next several decades and it is likely that warming of ocean temperatures will increase as well (Griffis and Howard 2013). While some variations in local temperature change are expected, ocean temperatures are expected to change globally and subsequently affect biological resources throughout the world's oceans.

Ocean acidification is one of the major changes in ocean chemistry as a result of increasing atmospheric CO_2 levels. Ocean acidification is the decrease in the pH of oceans associated with the uptake of atmospheric CO_2 and related chemical reactions (Griffis and Howard 2013). Absorption of atmospheric CO_2 by ocean surface waters has slowed the atmospheric greenhouse effect; however, CO_2 reacts with seawater and changes ocean chemistry (Griffis and Howard 2013). When CO_2 is absorbed into seawater it changes the relative concentrations of bicarbonate and carbonate ion in ocean water and due to the production of excess hydrogen ions, pH decreases (Griffis and Howard 2013).

Open ocean environments such as those of the BOA portion of the Action Area may be affected by climate change and ocean acidification. Changes in ocean stratification and circulation related to increasing ocean temperature have caused nutrient limitations and decreased primary production in open ocean environments (Brierley and Kingsford 2009). The reduced ocean mixing due to increasing ocean surface temperatures means that nutrients such as phosphate, silicate, and nitrate are limited in surface waters (Brierley and Kingsford 2009). Since these nutrients are essential to phytoplankton and algae growth, any nutrient limitation can decrease primary production (Brierley and Kingsford 2009). Because zooplankton populations (Brierley and Kingsford 2009) and those of other primary consumers are primarily limited by availability of their primary producer food sources, declines in production would be expected throughout the open ocean food web. Changing open ocean temperatures have also been associated with geographic shifts in species ranges (Brierley and Kingsford 2009). In the North Atlantic, distribution of plankton communities have changed by more than 10 degrees in latitude since the 1960s (Brierley and Kingsford 2009). As discussed above, any changes in the distribution of plankton communities would also be expected to change the distribution and abundance of organisms that feed on plankton as well as their predators.

Coral reef systems such as those found near Illeginni Islet are among the most diverse ecosystems on the planet. Coral reefs may be threatened by the physical, chemical, and biological changes in ocean waters associated with climate change and ocean acidification (Brierley and Kingsford 2009). Many coral species are integral components in coral reef ecosystems, providing physical structure and productivity. These corals require calcium carbonate to build exoskeletons; however, ocean acidification drives down the availability of calcium carbonate in ocean waters (Brierley and Kingsford 2009). Increased acidification is also thought to adversely affect coral fertilization, larval settlement, zooxanthellae acquisition rates, and stress levels affecting growth rates (Brainard et al. 2011).

Coral bleaching is another threat to coral reef ecosystems. The dinoflagellate algae (zooxanthellae) which are tissue-borne symbionts of many coral species, are also particularly sensitive to increasing ocean temperatures and this can lead to bleaching events (Brierley and Kingsford 2009, Marshall and Schuttenburg 2006). Coral color comes from the photosynthetic pigment in the zooxanthellae. Coral bleaching occurs when the colorful zooxanthellae are expelled from stressed coral hosts (Marshall and Schuttenburg 2006). Without zooxanthellae, coral tissues are largely transparent, and their white calcium carbonate skeleton is then visible (Marshall and Schuttenburg 2006). Loss of zooxanthellae also reduces the nutritional advantage that healthy corals receive symbiotically from the by-products of photosynthesis. Many local stressors may cause coral bleaching including disease, sedimentation, pollutants, and changes in salinity; however, a growing body of evidence indicates that the large-scale bleaching events observed in recent decades are closely associated with globally increasing sea temperatures (Marshall and Schuttenburg 2006). Even if corals survive bleaching events and repopulate their tissues with zooxanthellae; growth, reproduction, and resistance to disease may be reduced in corals subject to bleaching (Marshall and Schuttenburg 2006). Projections of global ocean temperature increases over the next several decades suggest that mass bleaching events are likely to be a more frequent in the future (Marshall and Schuttenburg 2006). Increases in frequency and severity of mass bleaching events are likely to decrease coral cover and lower coral biodiversity (Marshall and Schuttenburg 2006). These changes in coral abundance and diversity would likely alter the available habitat and food for other reef-associated species and subsequently community structure of these coral reefs (Marshall and Schuttenburg 2006).

The expected cumulative effects from these actions and considerations on species requiring consultation are discussed in the sections below.

6.2 Cumulative Effects on Listed Resources

6.2.1 Cumulative Effects on Marine Mammals

Consequences of cumulative impacts on marine mammals can manifest as any combination of loss of prey resources, behavioral disturbances from various human activities (such as vessel activity or military ordnance activities), acoustic disturbances, an increased chance of physical strikes or contact, or decreased resilience following disturbance (e.g., delayed or lack of recovery from induced stress or physiological changes back to a natural state).

Marine mammals have the potential to be impacted by the cumulative effects from commercial and recreational fishing, vessel traffic, ocean pollution, and climate change. Both bycatch and entanglement in fishing equipment are associated primarily with commercial fishing and are known to affect marine mammals. Along the US west coast there were 272 reported entanglements of whales between 1982 and 2010 (US Navy 2015b). While entanglements are generally more common in coastal areas with higher population, there is a risk anywhere commercial fishing takes place. Commercial and recreation fishing have also changed marine mammal prey populations throughout the Pacific which may have adverse consequences for marine mammal populations. The primary concerns of vessel traffic for marine mammals are vessel strikes and disturbance from underwater noise. Many whale species including blue whales, fin whales, sei whales, Bryde’s whales, minke whales, and humpback whales have been documented to have been hit by vessels (US Navy 2015b). While many odontocetes and pinnipeds seem to be less vulnerable to vessel strikes, most small whale and dolphin species have occasionally been struck by vessels (US Navy 2015b). Ocean noise from various sources is of concern regarding marine mammals as many species use sounds for navigating, finding prey, and communication (US Navy 2015b). Elevated noise levels in the ocean can mask these sounds and cause behavioral disturbance (US Navy 2015b). Marine mammal health and fitness may be reduced due to water pollution and marine debris. Elevated concentrations of some compounds have been detected in marine mammal tissue samples and while the effects are not well known, long-term exposure to pollutants may affect the health of individuals (US Navy 2015b). The effects of climate change and ocean acidification are likely to primarily impact marine mammals by prey availability and habitat suitability. All of these environmental considerations are expected to continue in the foreseeable future and may have adverse impacts on marine mammal populations.

Based on analyses in Section 5.0 (Effects of the Action), marine mammals are not likely to be adversely affected by FE-2 activities in the BOA portion of the Action Area or near Illeginni Islet. The Proposed Action is a single event taking place over a very short time period, and the probability of an FE-2 acoustic or direct contact effect is so low as to be discountable. Therefore, it is unlikely that FE-2 activities would contribute to or increase cumulative impacts on marine mammals.

6.2.2 Cumulative Effects on Birds

Consequences of cumulative effects on birds can manifest as any combination of loss of prey resources, behavioral disturbance from various human activities, acoustic disturbances, physical injury from acoustics or physical contact, or decreased resilience following disturbance (e.g., delayed or lack of recovery from induced stress or physiological changes back to natural state).

Newell’s shearwaters have the potential to be impacted by cumulative effects from commercial and recreational fishing, vessel traffic, ocean pollution and marine debris, and climate change and ocean acidification. Commercial and recreational fishing are of concern due to potential for seabird entanglement in fishing equipment and changes in seabird prey densities and distributions. While vessel strike has been known to be a cause of seabird mortality and injury (US Navy 2015b), it is unlikely to affect Newell’s shearwaters in the BOA due to the likely low density and scattered distribution of these birds. Ocean noise including elevated underwater sounds from vessels has the potential to impact birds through behavioral response, hearing loss, auditory masking, injury and even mortality (US Navy 2015b). Seabirds can become entangled in marine debris or can mistake debris for prey and ingest it (US Navy 2015b). A 2012 study concluded that as many as 44% of seabirds may be affected by plastic marine debris (US Navy 2015b). The effects of climate change and ocean acidification are likely to primarily impact Newell’s shearwaters by influencing prey availability and habitat suitability. All of these environmental considerations are expected to continue in the foreseeable future and may have adverse impacts on marine mammal populations.

Based on analyses in Section 5.0 (Effects of the Action), Newell’s shearwaters are not likely to be adversely affected by FE-2 activities in the BOA portion of the Action Area. The Proposed Action is a single event taking place over a very short time period, and Newell’s shearwaters have low densities in the Action Area. Therefore, it is unlikely that FE-2 activities would contribute to or increase cumulative impacts on Newell’s shearwaters or other seabirds.

6.2.3 Cumulative Effects on Sea Turtles

Consequences of cumulative impacts on sea turtles can manifest as any combination of loss of prey resources, behavioral disturbances from various human activities (such as vessel activity or military ordnance activities), acoustic disturbances, an increased chance of physical strikes or contact, or decreased resilience following disturbance (e.g., delayed or lack of recovery from induced stress or physiological changes back to a natural state).

Sea turtles have the potential to be impacted by cumulative effects from commercial and recreational fishing, subsistence and artisanal fishing, vessel traffic, ocean pollution and marine debris, and climate change and ocean acidification. Both bycatch and entanglement in fishing equipment are associated primarily with commercial fishing, and both are known to affect sea turtles. Bycatch is one of the primary threats to sea turtles. A 2010 study estimated that 447,000 sea turtles are killed each year in commercial fisheries bycatch worldwide (Wallace et al. 2010). Commercial and recreation fishing have also changed sea turtle prey populations throughout the Pacific, which may have adverse consequences for populations. In the RMI, subsistence and artisanal fishing remains a traditional and very important source of food for the Marshallese. Sea turtles are an important part of Marshallese culture; they are featured in many myths, legends, and traditions, where they are revered as sacred animals. Eating turtle meat and eggs on special occasions remains a prominent part of the culture. Presently, despite national and international protection as endangered species, marine turtles remain prestigious and a highly desired source of food in the RMI (Kabua and Edwards 2010). Turtles have long been a food source in the RMI, though the level of exploitation is unknown. Direct harvest of eggs and nesting adult females from beaches, as well as direct hunting of turtles in foraging areas, continues in many areas. The harvest of sea turtles in the RMI is regulated by the RMI Marine Resources Act, which sets minimum size limits for greens (86 cm [34 in] carapace length) and hawksbills (69 cm [27 in] carapace length) and closed seasons from June 1 to August 31 and December 1 to January 31. Egg collecting and take of turtles while they are onshore is prohibited (Kabua and Edwards 2010). The Marshall Islands Marine Resources Authority manages marine resources in the RMI.

The primary concerns of vessel traffic for sea turtles are vessel strikes and disturbance from underwater noise. Vessel strikes have been one of the leading causes of sea turtle mortality, and turtle strikes will likely continue to occur as maritime traffic increases in the oceans of the world (US Navy 2015b). While vessel strikes of sea turtles are higher in coastal areas with more vessel traffic, sea turtle strikes may still occur in the open ocean. The effects of vessel strikes have a wide range of severity; however, major strikes are known to cause permanent physical injury or death (US Navy 2015b). Ocean noise from various sources is of concern for sea turtles as it may induce behavioral reactions, hearing loss, auditory masking, or for extremely loud noises, mortality. Health and fitness of sea turtles may be reduced due to water pollution and marine debris. Marine debris can adversely affect sea turtles when they become entangled or when they mistake debris for food and ingest it (US Navy 2015b). In a 2009 study (Mrosovsky et al. 2009), researchers found that 37% of dead leatherback turtles had ingested some type of plastic. Since sea turtles must come to the surface to breathe, if a sea turtle in any life stage were to become entangled in marine debris, it may drown (US Navy 2015b). Climate change and ocean acidification are likely to impact sea turtles primarily by influencing prey availability and decreasing habitat suitability both in the ocean and in terrestrial nesting areas. As sea levels rise, less beach habitat that is suitable for sea turtle nesting may be available. There are also concerns about sea turtle egg development as global temperatures increase. The sex of hatchling sea turtles is determined by temperature during development, with females developing at warmer temperatures and males at cooler temperatures (Lolavar and Wyneken 2015). Incubation temperatures within sea turtle nests vary with environmental conditions which affect sand temperature including rainfall, sun exposure, and sand type

(Lolavar and Wyneken 2015). Variations in global temperatures and precipitation outside of normal variation may have serious implications for sea turtle populations. All of the above environmental considerations are expected to continue in the foreseeable future and may have adverse impacts on sea turtle populations.

Based on analyses in Section 5.0 (Effects of the Action), sea turtles in the ocean are not likely to be adversely affected by FE-2 activities in the BOA portion of the Action Area or near Illeginni Islet. The Proposed Action is a single event taking place over a very short time period, and sea turtles have low densities in the Action Area. The probability of an FE-2 acoustic or direct contact effect is so low as to be discountable; therefore, it is unlikely that FE-2 activities would contribute to or increase cumulative impacts on sea turtles in marine habitats.

It is possible that FE-2 activities may damage green or hawksbill turtle suitable nesting habitat on Illeginni Islet. Sea turtle nesting habitat may be adversely affected through direct contact by payload debris or ejecta, exposure to hazardous chemicals, and disturbance from human activity and equipment operation. Suitable sea turtle nesting habitat occurs near the Action Area at Illeginni Islet; however, no nesting activity has been recorded on Illeginni Islet in over 20 years. Although the proposed FE-2 activities have the potential to adversely impact green or hawksbill turtle suitable nesting habitat, any realized effect would be very small in relation to turtle nesting populations at Kwajalein Atoll or in the central west Pacific. Therefore, the contribution of FE-2 activities to cumulative impacts on sea turtles would be minimal.

6.2.4 Cumulative Effects on Fish

Consequences of cumulative impacts on fish can manifest as any combination of loss of prey resources, behavioral disturbances from various human activities (e.g., vessel activity or military ordnance activities), an increased chance of physical strike or contact, or decreased resilience following disturbance (e.g., delayed or lack of recovery from induced stress or physiological changes back to a natural state).

Fish have the potential to be impacted by cumulative effects from commercial and recreational fishing, subsistence and artisanal fishing, vessel traffic, ocean pollution and marine debris, and climate change and ocean acidification. Commercial and recreational fishing are of concern to fish due to targeted fishing, bycatch, and changes in community composition. Overfishing and bycatch from commercial fishing is listed as one of the most serious threats leading to listing (or proposed listing) for all consultation fish in the Action Area (see Section 4.4). Due to overharvest and bycatch, oceanic whitetip shark populations have decreased approximately 90% from 1996 to 2009 (Defenders of Wildlife 2015c) and Pacific bluefin tuna populations have decreased to approximately 2.6% of their estimated unfished biomass (CBD 2016). In the RMI, tuna comprise 90% of the annual catch from locally-based offshore fisheries and a majority of the foreign-based offshore fishing in the Marshall Islands Zone as well (FAO 2009). While subsistence and artisanal fishing in the RMI is a fraction of the total fish harvest in the Action Area, it affects UES consultation fish species and remains a consideration in cumulative effects. MIMRA is responsible for both offshore and coastal fisheries in the Marshall Islands including a management plan for tuna with longline limits for bigeye tuna (FAO 2009). There are also regional efforts to limit the number of purse seine fishing days in Pacific Island countries (FAO 2009).

The effects of vessel traffic on fish is generally limited to causing avoidance behaviors; however, there is some evidence that juvenile fish might be affected by cavitation from a vessel’s propeller movement or propeller wash. Ocean noise including elevated underwater sounds from vessels has the potential to impact fish through behavioral response, hearing loss, auditory masking, injury and even mortality (US Navy 2015b). In the open ocean, chemical pollution is not generally an immediate threat to fish; however, increasing evidence of bioaccumulation of pollutants in fish and other organisms is a growing concern (US Navy 2015b). As with other organisms, fish can also become entangled in marine debris or can mistake debris for food and ingest it (US Navy 2015b). The effects of climate change and ocean acidification are likely to impact fish primarily by influencing prey availability and habitat suitability. Changing ocean temperatures may alter prey availability and distribution both in the open ocean and in nearshore areas. For reef associated species such as the humphead wrasse and the reef manta ray, changes in coral reef habitat as discussed in section 6.1.4 can affect food availability, cover, and overall health and resilience of these fish. All of these environmental considerations are expected to continue in the foreseeable future and may have adverse impacts on fish populations, especially reef-associated species.

Based on analyses in Section 5.0 (Effects of the Action), adult fish in the BOA portion of the Action Area, as well as reef manta rays and scalloped hammerhead sharks at Kwajalein Atoll, are not likely to be adversely affected by FE-2 activities. The Proposed Action is a single event taking place over a very short time period, and UES consultation fish species have low densities and patchy distributions in the Action Area. Therefore, it is unlikely that FE-2 activities would contribute to or increase cumulative impacts on fish.

A small but inestimable number of larval fish may be affected by FE-2 activities; however, given the scope of the action and the very small proportion of total fish larvae likely to be affected, it is unlikely that FE-2 activities would contribute to or increase cumulative impacts on larval fish.

The humphead wrasse may be adversely affected by payload impact at Illeginni Islet due to direct strike and disturbance from human activity and equipment operation. A maximum of 8 adult and 100 juvenile humphead wrasses would be affected in the worst-case scenario of a shoreline payload impact (Section 5.1.2). While the total population of the humphead wrasse is not known for the waters surrounding Illeginni Islet or for Kwajalein Atoll, the number of wrasses potentially affected is likely a very small fraction of the total population. Because this is a one-time event and a shoreline strike is not anticipated, it is unlikely that FE-2 activities would significantly increase cumulative impacts on humphead wrasses.

6.2.5 Cumulative Effects to Corals and Mollusks

Consequences of cumulative impacts on corals and mollusks can manifest as any combination of loss of biomass or diversity, decreased resistance to disturbance, or decreased resilience following disturbance (e.g., delayed or lack of recovery from disturbance; Connell 1997, Hughes and Connell 1999, Jaap 2000, Porter et al. 1999, Rogers and Garrison 2001). The USFWS/NMFS biological inventories have revealed relatively poor reef habitat conditions on the shallower northwestern ocean-side reef at Illeginni (USFWS and NMFS 2002, 2004, and 2006). This area is exposed to strong waves from the south and west and, more than other reefs at Illeginni Islet, is exposed to the effects of a variety of activities including past and ongoing missile tests, unexploded ordnance disposal, and aircrew training missions (USFWS and NMFS 2002, and 2006). The relatively poor habitat conditions observed on the shallow northwestern ocean-side portion of the Illeginni reef is more likely to be associated with the cumulative effects of USAKA activities and natural processes. Disentangling the consequences of individual causes of effects in marine systems is very difficult (Fabricius 2005, Nyström et al. 2008). Even if prior missile flight test impacts could not be parsed out, they were a likely contributor to the area’s present condition.

Corals and mollusks have the potential to be impacted by cumulative effects from commercial and recreational fishing, subsistence and artisanal fishing, vessel traffic, ocean pollution and marine debris, and climate change and ocean acidification. Commercial and recreational fishing affect corals and mollusks through targeted fishing, bycatch, and habitat alteration. Part of the fisheries catch in the RMI includes non-food commodities such as mollusks, aquarium fish, and corals (FAO 2009). Exports from the coastal commercial fisheries are primarily aquarium fish and coral for US markets and top shell snails for button factories in Asia and Europe (FAO 2009). The aquarium fishery operating at Majuro and Eniwetak Atolls supports most of the top shell snail catch (FAO 2009). While subsistence and artisanal fishing in the RMI is likely a small portion of the total coral and mollusk harvest in the Action Area, the fishery likely affects UES consultation species and remains a consideration in cumulative effects. MIMRA is responsible for coastal fisheries management in the Marshall Islands including a prohibition on taking *Tectus* (*Trochus*) except during a short open season (FAO 2009). Some fishing methods or marine debris created from abandoned fishing equipment can damage corals in reefs. Lost or abandoned traps, nets, and lines from fisheries can damage corals in reefs.

The main effect of vessel traffic on coral and mollusks is the effect of cavitation on larvae. Cavitation from vessels traveling through an area could lead to decreased fertilization, larval deformities, or even larval death (NMFS 2015b). Studies have provided evidence that larvae subject to highly turbulent water may die or have abnormal development (NMFS 2015b). While very little is known about the sensitivity of invertebrates to sound (Hawkins and Popper 2012), elevated sounds in the ocean have the potential to impact coral and mollusks. Many marine invertebrates are able to detect sounds (Hawkins and Popper 2012) and even coral larvae have been known to orient in response to acoustic cues in reefs (Vermeij et al 2010). In the open ocean, chemical pollution is not generally an immediate threat to coral and mollusk species; however, increasing evidence of bioaccumulation of pollutants in fish and other organisms is a growing concern (US Navy 2015b). As with other organisms, corals and mollusks can become entangled in or inadvertently ingest particles of marine debris. The effects of climate change and ocean acidification on corals is detailed in Section 6.1.4. Mollusks would be affected by many of the same factors, and any effects to corals that change reef dynamics or structure would also affect reef-associated mollusks. All of these environmental considerations are expected to continue in the foreseeable future and may have adverse impacts on fish populations, especially reef-associated species.

Based on analyses in Section 5.0 (Effects of the Action), a small but inestimable number of larval coral and mollusks may be affected in the BOA portion of the Action Area and near Illeginni Islet. Even though a small number of larvae may be affected, FE-2 actions are not likely to adversely affect larval and coral mollusks as the number of larvae affected would be extremely small relative to the total number of larvae in the Action Area. Marine larvae are often found in patch distributions driven by wind and waves and at varying abundances during the year due to their seasonal spawning habits. The Proposed Action is a single event taking place over a very short time period, and the effects of taking individual coral or mollusk larvae are minimal. Therefore, it is unlikely that FE-2 activities would contribute to or increase cumulative impacts on larval coral or mollusks.

Adult consultation corals and mollusks do not occur in the BOA portion of the Action Area. Near Illeginni Islet, adult corals and mollusks may be affected by direct contact, exposure to hazardous chemicals, and disturbance from human activity. Seven species of consultation coral (*Acropora microclados, A. polystoma, Cyphastrea agassizi, Heliopora coerulea, Pavona venosa, Pocillopora meandrina,* and *Turbinaria reniformis*) and three mollusk species (*Hippopus hippopus, Tectus niloticus,* and *Tridacna squamosa*) may be adversely affected by direct contact from payload debris or impact ejecta or by disturbance from human activity or equipment operation (Section 5.1). These analyses were based on the worst-case scenario of a shoreline strike. A shoreline strike is not expected; however, if it were to occur, a maximum of 5,692 coral colonies and 79 individual mollusks might be impacted at Illeginni Islet. The Proposed Action is a one-time event, and the likelihood of a shoreline impact is low (but unknowable). Therefore, it is unlikely that FE-2 activities would significantly increase cumulative impacts on these species.

6.3 Cumulative Effects Related to Climate Change and Ozone Depletion

Solid propellant rocket motors release several chemicals and compounds which may contribute to climate change and ozone depletion. The main rocket exhaust products that can contribute to ozone depletion are hydrochloric acid (HCl) and alumina (Al_2O_3; Ross et al. 2010). In the stratosphere, emissions of HCl react with oxygen to produce ozone-damaging chlorine oxides (Ross et al. 2009). Globally, rockets are becoming a serious concern with regard to ozone layer depletion (Ross et al. 2009). Alumina is another main exhaust product of rockets, but very little is known about ozone loss from alumina particles (Ross et al. 2009). Ross et al. (2009) report that "only alumina particles smaller than 1 µm remain in the stratosphere for years and contribute to the steady-state ozone loss. The fraction of [solid rocket motor] alumina particles that meet this criterion has been variously reported as between 1% and 30%."

The main rocket exhaust products that can contribute to climate change are CO_2 and soot or black carbon particulate (Ross et al. 2010). The effects of CO_2 on global warming are fairly well documented and some effects are outlined in Section 6.1.4. Globally, annual emissions of CO_2 from rockets (several kilotons) are estimated to be a fraction of CO_2 emissions from aircraft (several hundred kilotons), which is only a few percent of the total annual CO_2 emissions from all sources (Ross et al. 2009). Particles emitted by rockets such as alumina, metallic debris, and soot or black carbon particulate, contribute to the radiative properties of the atmosphere by absorbing visible light (Ross et al. 2010). When sunlight enters the earth's atmosphere, black carbon absorbs visible light, subsequently warming the atmosphere. Toohey (n.d.) states that "it is estimated that black carbon emitted by rockets is over one million times more efficient at heating the atmosphere than an equivalent amount of CO_2 by weight." Black carbon in the lower atmosphere is removed within months by rain and dry deposition; however, black carbon can remain in the upper atmosphere for 5-10 years (Toohey n.d). Compared to aircraft, rockets emit several orders of magnitude more black carbon (per propellant; Ross et al. 2010). While Ross et al. (2009) state that rockets are likely a minuscule contributor to the problem of climate change, any rocket launch has some small contribution to climate change which should be considered in cumulative effects.

While the cumulative effects of rocket launches on climate change and ozone depletion may be real and serious and the FE-2 launch will produce emissions which will contribute to climate change and ozone depletion, the single FE-2 flight test is unlikely to significantly contribute to or increase the cumulative effects of climate change or ozone depletion.

7.0 CONCLUSIONS

Based on analyses of all of the potential stressors in the Action Area, we have determined that the Proposed Action would have no effect on 24 cetacean species, Hawaiian monk seals, Newell's shearwaters, 5 sea turtle species, 2 species of sharks, Oceanic giant manta rays, Pacific bluefin tuna, or larval fish, corals, and mollusks in the BOA of the Action Area (Table 7-1).

We have determined that the Proposed Action "may affect but is not likely to adversely affect" 11 cetacean species, green turtles, hawksbill turtles, reef manta rays, Oceanic giant manta rays,15 coral species, 2 mollusk species, and larval fish, corals, and mollusks near Illeginni Islet (Table 7-1). These species typically have low densities and patchy distributions in the Action Area, and the probability of animals being in the area of injury, death, or behavioral disruption is considered insignificant or discountable. It is likely that a relatively small and undeterminable number of fish, coral, or mollusk larvae will be adversely affected in surface waters within some portions of the Action Area. However, because the affected areas are trivially small relative to the distribution of these invertebrates and because the number of larvae potentially affected is likely to be trivially small relative to their population sizes, these adverse effects are considered insignificant and discountable.

We also determined that in in the vicinity of Illeginni Islet, the Proposed Action "may affect and is likely to adversely affect" the humphead wrasse, seven coral species (*Acropora microclados, A. polystoma, Cyphastrea agassizi, Heliopora coerulea, Pavona venosa, Pocillopora meandrina,* and *Turbinaria reniformis*) and three mollusk species (*Hippopus hippopus, Tectus niloticus,* and *Tridacna squamosa*) (Table 7-1). Based on the best available information about species distributions and the effects of the stressors, the humphead wrasse, seven species of coral, and three species of mollusk may be adversely affected by direct contact from payload debris and ejecta or by disturbance from human activity or equipment operation. All of these species are known to occur on at least 5 of the 10 other islets surveyed in Kwajalein Atoll (Tables 4-6, 4-7, and 4-8) as well as in the Mid-Atoll Corridor. Considering the worst-case scenario of a shoreline payload impact, analyses provide evidence that a maximum of 8 adult or 100 juvenile humphead wrasse, 5,692 coral colonies, and 79 individual mollusks might be affected by FE-2 activities (detailed in Section 5.1.2).

We determined that the Proposed Action may affect but is not likely to adversely affect Newell's shearwaters at KTF.

There is no designated critical habitat for any listed species in the Action Area.

Table 7-1
Effect Determinations for Species Requiring Consultation‡ in the Action Area
("-"= not known to be present in effect area, x = no effect, ○=may affect but not likely to adversely affect, ●=may affect and likely to adversely affect).

Scientific Name	Common Name	BOA					Vicinity of Illeginni Islet				
		Elevated Sound	Direct Contact	Vessel Strike	Hazard. Chem.	Human Disturb.	Elevated Sound	Direct Contact	Vessel Strike	Hazard. Chem.	Human Disturb.
Cetaceans											
Balaenoptera acutorostrata	Minke whale	x	x	x	x	x	x	-	○	-	○
B. borealis	Sei whale	x	x	x	x	x	-	-	-	-	-
B. edeni	Bryde's whale	x	x	x	x	x	x	-	○	-	○
B. musculus	Blue whale	x	x	x	x	x	-	-	-	-	-
B. physalus	Fin whale	x	x	x	x	x	-	-	-	-	-
Delphinus delphis	Short-beaked common dolphin	-	-	-	-	-	x	-	○	-	○
Feresa attenuata	Pygmy killer whale	x	x	x	x	x	-	-	-	-	-
Globicephala macrorhynchus	Short-finned pilot whale	x	x	x	x	x	x	-	○	-	○
Grampus griseus	Risso's dolphin	x	x	x	x	x	-	-	-	-	-
Indopacetus pacificus	Longman's beaked whale	x	x	x	x	x	-	-	-	-	-
Kogia breviceps	Pygmy sperm whale	x	x	x	x	x	-	-	-	-	-
K. sima	Dwarf sperm whale	x	x	x	x	x	-	-	-	-	-
Lagenodelphis hosei	Fraser's dolphin	x	x	x	x	x	-	-	-	-	-
Megaptera novaeangliae	Humpback whale	x	x	x	x	x	-	-	-	-	-
Mesoplodon densirostris	Blainville's beaked whale	x	x	x	x	x	-	-	-	-	-
Orcinus orca	Killer whale	x	x	x	x	x	x	-	○	-	○
Peponocephala electra	Melon-headed whale	x	x	x	x	x	x	-	○	-	○
Physeter macrocephalus	Sperm whale	x	x	x	x	x	x	-	○	-	○
Pseudorca crassidens	False killer whale	x	x	x	x	x	-	-	-	-	-
Stenella attenuata	Pantropical spotted dolphin	x	x	x	x	x	x	-	○	-	○
S. coeruleoalba	Striped dolphin	x	x	x	x	x	x	-	○	-	○
S. longirostris	Spinner dolphin	x	x	x	x	x	x	-	○	-	○
Steno bredanensis	Rough-toothed dolphin	x	x	x	x	x	-	-	-	-	-
Tursiops truncatus	Bottlenose dolphin	x	x	x	x	x	x	-	○	-	○
Ziphius cavirostris	Cuvier's beaked whale	x	x	x	x	x	-	-	-	-	-
Phocids											
Neomonachus schauinslandi	Hawaiian monk seal	x	x	x	x	x	-	-	-	-	-
Birds											
Puffinus auricularis newelli	Newell's shearwater	x	x	x	x	x	-	-	-	-	-

Scientific Name	Common Name	BOA					Vicinity of Illeginni Islet				
		Elevated Sound	Direct Contact	Vessel Strike	Hazard. Chem.	Human Disturb.	Elevated Sound	Direct Contact	Vessel Strike	Hazard. Chem.	Human Disturb.
Sea Turtles											
Caretta caretta	Loggerhead turtle	x	x	x	x	x	-	-	-	-	-
Chelonia mydas	Green turtle	x	x	x	x	x	○	○	○	○	○
Dermochelys coriacea	Leatherback turtle	x	x	x	x	x	-	-	-	-	-
Eretmochelys imbricata	Hawksbill turtle	x	x	x	x	x	○	○	○	○	○
Lepidochelys olivacea	Olive ridley turtle	x	x	x	x	x	-	-	-	-	-
Fish (non-larval)											
Alopias superciliosus	Bigeye thresher shark	x	x	x	x	x	-	-	-	-	-
Carcharhinus longimanus	Oceanic whitetip shark	x	x	x	x	x	-	-	-	-	-
Cheilinus undulatus	Humphead wrasse	-	-	-	-	-	○	●	○	○	●
Manta alfredi	Reef manta ray	-	-	-	-	-	○	○	○	○	○
M. birostris	Oceanic giant manta ray	x	x	x	x	x	○	○	○	○	○
Sphyrna lewini	Scalloped hammerhead	-	-	-	-	-	○	-	○	-	○
Thunnus orientalis	Pacific bluefin tuna	x	x	x	x	x	-	-	-	-	-
Corals (non-larval)											
Acanthastrea brevis		-	-	-	-	-	x	○	○	○	○
Acropora aculeus		-	-	-	-	-	x	○	○	○	○
A. aspera		-	-	-	-	-	x	○	○	○	○
A. dendrum		-	-	-	-	-	x	○	○	○	○
A. listeri		-	-	-	-	-	x	○	○	○	○
A. microclados		-	-	-	-	-	x	●	○	○	●
A. polystoma		-	-	-	-	-	x	●	○	○	●
A. speciosa		-	-	-	-	-	x	○	○	○	○
A. tenella		-	-	-	-	-	x	○	○	○	○
A. vaughani		-	-	-	-	-	x	○	○	○	○
Alveopora verrilliana		-	-	-	-	-	x	○	○	○	○
Cyphastrea agassizi		-	-	-	-	-	x	●	○	○	●
Heliopora coerulea		-	-	-	-	-	x	●	○	○	●
Leptoseris incrustans		-	-	-	-	-	x	○	○	○	○
Montipora caliculata		-	-	-	-	-	x	○	○	○	○
Pavona cactus		-	-	-	-	-	x	○	○	○	○
P. decussata		-	-	-	-	-	x	○	○	○	○
P. venosa		-	-	-	-	-	x	●	○	○	●
Pocillopora meandrina		-	-	-	-	-	x	●	○	○	●
Turbinaria mesenterina		-	-	-	-	-	x	○	○	○	○
T. reniformis		-	-	-	-	-	x	●	○	○	●
T. stellulata		-	-	-	-	-	x	○	○	○	○

Scientific Name	Common Name	BOA: Elevated Sound	BOA: Direct Contact	BOA: Vessel Strike	BOA: Hazard. Chem.	BOA: Human Disturb.	Vicinity of Illeginni Islet: Elevated Sound	Vicinity of Illeginni Islet: Direct Contact	Vicinity of Illeginni Islet: Vessel Strike	Vicinity of Illeginni Islet: Hazard. Chem.	Vicinity of Illeginni Islet: Human Disturb.
Mollusks (non-larval)											
Hippopus hippopus	Giant clam	-	-	-	-	-	x	●	○	○	●
Pinctada margaritifera	Black-lipped pearl oyster	-	-	-	-	-	x	○	○	○	○
Tectus niloticus	Top shell snail	-	-	-	-	-	x	●	○	○	●
Tridacna gigas	Giant clam	-	-	-	-	-	x	○	○	○	○
T. squamosa	Giant clam	-	-	-	-	-	x	●	○	○	●
Larval Fish, Coral, and Mollusks		x	x	x	x	x	x	○	○	○	○

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APPENDIX A
ANALYSIS OF FE-2 SONIC-BOOM AND STAGE DROP ACOUSTICS

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References:

(a) Simplified Sonic-Boom Prediction, NASA Technical Paper 1122, H. W. Carlson, 1972
(b) Trident II (D5) Pacific Missile Testing OEA, Department of the Navy – SSP, August 2004

A1 Introduction

The Flight Experiment-2 (FE-2) flight test will consist of a launch point to target test of a flight experiment. During flight, the payload is boosted by three stages to exoatmospheric altitudes. Following boost, the payload is deployed, re-enters the atmosphere, and travels to the impact area. During flight, a significant acoustic signature is generated by the boost and motor exhaust, sonic boom of the missile/payload, and lastly, the stage motor impacts with the ocean surface. The following analysis focuses on the acoustic disturbance created by the sonic boom and stage nose fairing impacts but does not consider the boost and motor exhaust.

Figure A-1 is an illustration of a shock wave generated by a vehicle traveling at hypersonic speeds. A sonic boom is the acoustic signature of the shock wave heard or detected by an observer – typically on the ground. It is comprised of a sharp increase in pressure over and above the atmospheric pressure

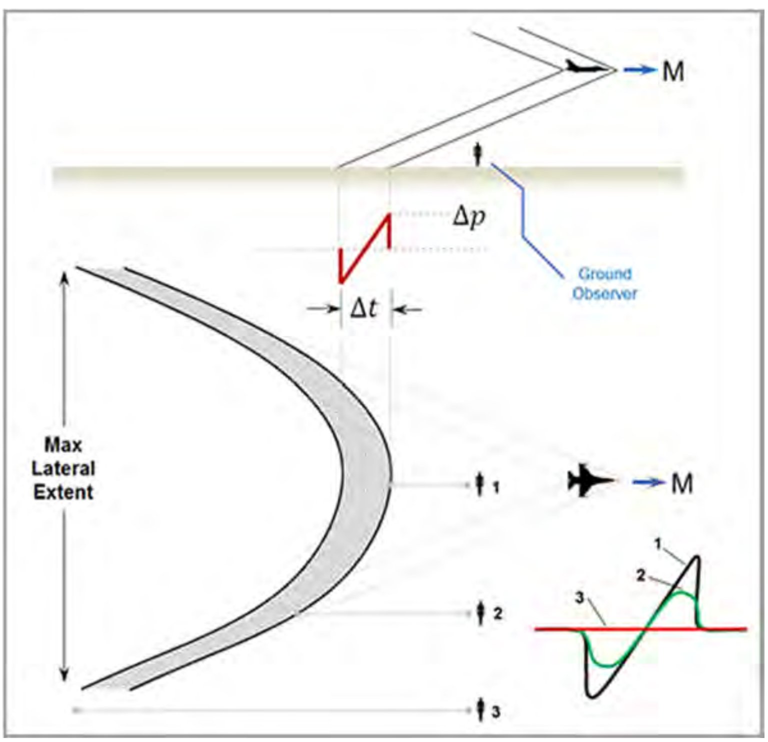


Figure A-1. Sonic Boom Illustration

(overpressure) followed by a decrease to an underpressure and then rapid rise back to atmospheric pressure. This signature is commonly referred to as an "N-wave". The intensity of the sonic boom, if any, will vary depending on the location of a ground observer and is directly proportional to the peak overpressure. This intensity will be greatest for an observer directly under the flight path of the vehicle. As an observer moves cross range (or off track) to the flight path, the intensity will decrease and the time the sonic boom reaches the observer will be delayed relative to the observer directly beneath. Eventually, a point is reached cross range where the sonic boom disappears. The peak overpressure and hence intensity of the sonic boom is not only a function of an observer's location, but a number of variables including the altitude of the vehicle, its Mach number, atmospheric effects, etc.

In addition to the sonic boom, which is essentially dragged along the flight path of the vehicle, there are significant local acoustic disturbances created by the impacts of the three stages and nose fairing with the ocean surface due to the amount of kinetic energy these bodies have prior to impact. Per body, the kinetic energy at splash of the FE-2 stages is on the order of a ton (2,000 lb) of TNT (4×10^9 J). However, only a fraction (~1%) of this energy is actually converted to acoustic energy.

The following sections will outline the methodology and subsequent results of calculating the FE-2 flight test acoustic intensities as well as affected areas associated with both the sonic boom throughout the payload trajectory and stage impacts.

A2 Methodology

One of the main objectives of this analysis was to provide a means of predicting the total affected sea-surface area (km^2) for a given sound intensity (dB). This allows analysts the ability to then specify critical sound intensities and estimate the level of harm to animal species given knowledge of their geographic densities.

A2.1 Sonic Boom

The intensity of the sonic boom generated by the vehicle during flight is logarithmically proportional to the overpressure of the shock wave, which is in turn, a strong function of the size and shape of the body under consideration. Interestingly, the strength of the sonic boom is weakly dependent on vehicle Mach number. Following the procedure(s) outlined in Reference (a), Appendix A shows the step by step process of calculating the overpressure and hence intensity of the vehicle sonic boom at any observation point given its Mach number, altitude, and shape characteristics. A number of important assumptions were made for the calculation of the sonic boom intensity and are itemized below:

1) Atmospheric conditions were assumed zero wind, with pressure, temperature and other properties a function of altitude according to the 1976 Standard Atmosphere model.
2) The ocean surface was assumed to be perfectly flat, i.e., a World Meteorological Organization (WMO) Sea State code of 0.
3) The "N-Wave" shock wave and hence sonic boom was assumed to have 100% transmission between the air and ocean interface at all observation points at sea-level.
    a. In reality, only a fraction of the shock wave will transmit into the water at the surface. This fraction is heavily dependent on flight path angle and shock wave to water surface incident angle, i.e. sea state.
4) During boost, the stages are modeled as perfect cylinders with diameters and lengths identical to the actual stages. Similarly, the payload is modeled as a perfect cone. This approximation is more than adequate for the purposes of this analysis.

5) Stage exhaust / plume acoustics is not modeled or accounted for.
6) Unless otherwise noted, all quoted intensity values (dB) were calculated relative to a reference pressure of 1 μPa, the convention for sound intensity in water.
    a. Note that typically, sound intensity in air is reported as dB relative to a reference pressure of 20 μPa. It is easy to show that one may convert from the water to air reference by simply subtracting 26 dB from the water value.

The above assumptions are extraordinarily conservative and may yield predicted overpressures as much as an order of magnitude larger (20 dB increase in intensity) than what will occur in reality. This is primarily due to the lack of additional information regarding specific sea states, which even then, would require additional second to third order modeling techniques to refine the prediction. Nonetheless, the predicted values here do provide an upper end estimate of the sonic boom intensity.

Given the above assumptions and procedures outlined in Reference (a), the nominal FE-2 flight trajectory was processed to calculate the overpressure and intensity at a series of observation points at sea level for each time of the trajectory. Note that the resultant observation points are not necessarily directly beneath the vehicle but spread out up range and cross range of the ground trace. A series of contours are then generated from these calculations from which the “affect area” for a given intensity level is then calculated.

A2.2 Stage Impact

Calculation of the acoustical disturbance due to the stage impacts relied heavily upon the equations in Reference b. The state vectors of each stage at release were used to calculate, i.e., propagate the stage during its re-entry to the surface resulting in a final velocity vector at impact. This velocity vector, along with the stage mass can then be converted into kinetic energy. Much like the methodology in the case of calculating the sonic boom intensity, a number of assumptions were employed with the stage impact calculation:

1) Atmospheric conditions were assumed zero wind, with pressure, temperature and other properties a function of altitude according to the 1976 Standard Atmosphere model.
2) The ocean surface was assumed to be perfectly flat, i.e., a WMO Sea State code of 0.
3) Acoustic intensity (dB) values were calculated based on empirical equations (Appendix B) determined from Trident II (D5) stage impacts. These equations were a function of kinetic energy at impact.
    a. Note that these relations assume 1% of the kinetic energy is actually converted to acoustic energy.
    b. Also note that, like the sonic boom calculations, the intensity values (dB) are also relative to a reference pressure of 1×10^{-6} Pa (dB re 1 μPa).
4) The kinetic energy of each stage at impact is a function of its velocity at that time which is strongly dependent on the mass and drag of the stage (ballistic coefficient). Due to insufficient data, for the purpose of this analysis, two drag values were used, CD = 1 and CD = 3. Note that higher CD values lead to lower impact velocities and hence lower acoustical intensity. Thus, a drag coefficient value of 1 is relatively conservative as the value of CD for a tumbling cylinder is generally 3 or greater.
5) The noise signature of the stage impacts were assumed to be similar to the noise signature of stage impacts of the D5 missile as discussed in Reference (b).

The equations outlined in Appendix B along with the assumptions cited above were implemented into a set of scripts to calculate the peak sound intensity at impact along with the sound intensity as a function of distance from impact area. The latter of which was then used to calculate the affect area as a function of dB intensity.

A3 Results

Table A-1 shows the sonic boom intensity at various sea-level locations directly below several reference points of the trajectory:

Table A-1
Sonic Boom Intensity in Water at Various Reference Locations

Reference	Intensity (dB re 1 μPa)
Boost (Maximum)	145
Flight (Maximum)	135
Flight (Average)	130
Terminal (Maximum)	175

While Table A-1 shows the local impact of the sonic boom, as mentioned in Section A2 (Methodology), the overall goal of this analysis was to provide a means for an analyst to predict the area affected by a certain acoustic intensity level for both the sonic boom and stage impacts. Figure A-2 is such a plot showing (semi-log) Affect Area (km^2) as a function of acoustic level (dB re 1 μPa). Table A-2 contains the actual numerical values from Figure A-2.

Values in sound intensity in Figure A-2 and Table A-2 show that the sonic boom has a much larger affect area at levels less than ~175 dB re 1 μPa relative to the stage impacts. This is primarily due to the large swath of ocean over which the shock wave interacts. However, for values above ~175 dB re 1 μPa, the stage impacts dominate with affected areas of 1 km^2 or less. Also note the difference in the CD = 1 vs. CD = 3 stage impact intensity where the values associated with CD = 1 are approximately 7 dB larger.

While peak acoustic intensities and the areas affected by these disturbances are of primary interest, there is also a secondary interest in the frequency composition as well as duration of the disturbances. Section A3.3 contains plots of the frequency makeup of both the sonic boom and stage impacts. Regarding disturbance duration, the sonic boom duration is variable and a function of the vehicle size, altitude, and Mach number. For the FE-2 flight trajectory, the duration of the sonic boom is on average:

- ~268 ms for intensities less than 140 dB re 1 μPa
- ~75 ms for intensities greater than 140 dB re 1 μPa

Estimates of the duration of the acoustical disturbance from a spent object impact are difficult to make with the same level of precision. The estimated duration of an individual impact event will be on the order of a few seconds.

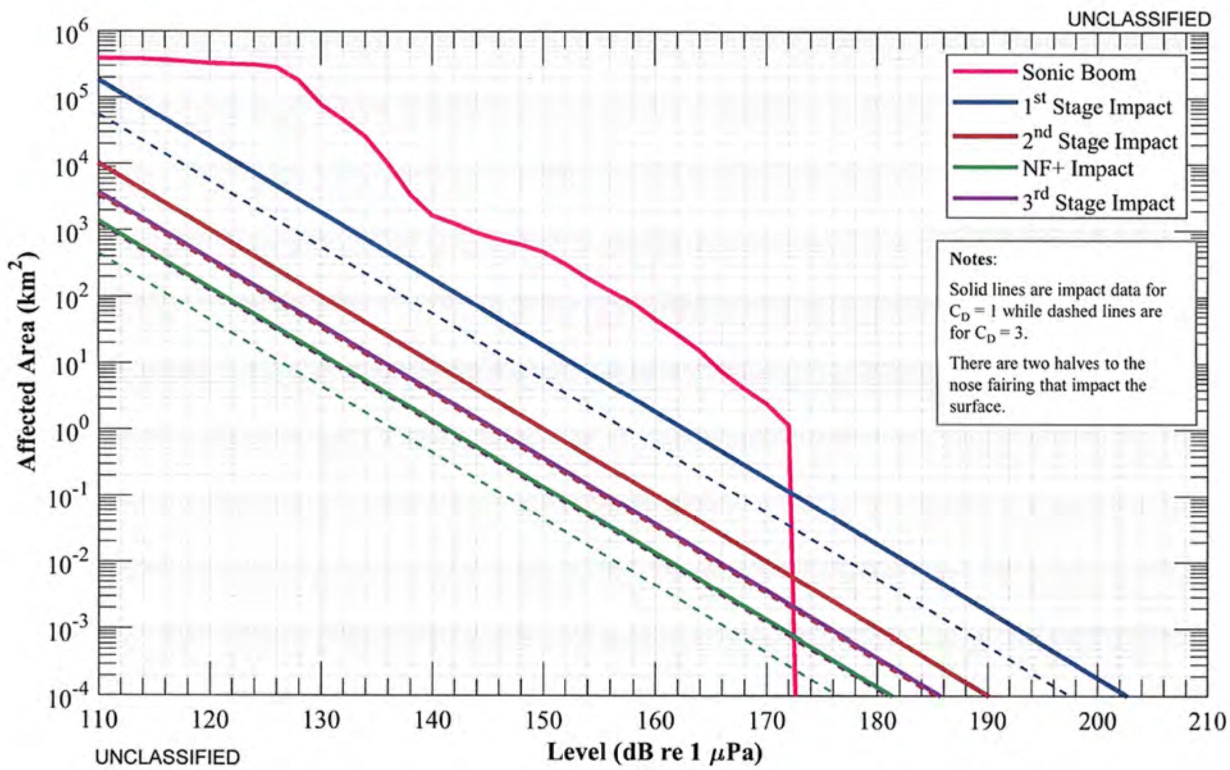


Figure A-2. Plot of Area Affected vs. Sound Intensity for Sonic Boom and Stage Impacts.

Table A-2
Tabular Values of Affected Area (km²).

dB re 1 μPa	Sonic Boom	1st Stage		2nd Stage		Nose Fairing		3rd Stage	
		Cd = 1	Cd = 3	Cd = 1	Cd = 3	Cd = 1	Cd = 3	Cd = 1	Cd = 3
100	411,960	1,850,283	562,109	102,221	33,380	13,549	4,481	37,191	12,239
110	390,003	185,028	56,211	10,222	3,338	1,355	448	3,719	1,224
120	331,551	18,502	5,621	1,022	334	136	45	372	123
130	78,654	1,850	562	102	33	14	4.5	37	12
140	1,666	185	56	10	3.3	1.4	0.45	3.7	1.2
150	474	19	5.6	1.0	0.33	0.14	0.045	0.37	0.12
160	45	1.9	0.56	0.1	0.033	0.014	0.0045	0.037	0.012
170	2.4	0.19	0.056	0.01	0.0033	0.0014	0.00045	0.0037	0.0012
180	0	0.019	0.0056	0.001	0.00033	0.00014	0.000045	0.00037	0.00012
190	0	0.0019	0.00056	0.0001	0.000033	0.000014	4.5 x 10-6	0.000037	0.000012
200	0	0.00019	0.000056	0.00001	3.3 x 10-6	1.4 x 10-6	4.5 x 10-7	3.7 x 10-6	1.2 x 10-6
210	0	0.000019	5.6 x 10-6	1 x 10-6	3.3 x 10-7	1.4 x 10-7	4.5 x 10-8	3.7 x 10-7	1.2 x 10-7
220	0	1.9 x 10-6	5.6 x 10-7	1 x 10-7	3.3 x 10-8	1.4 x 10-8	4.5 x 10-9	3.7 x 10-8	1 x 10-8

A3.1 Sonic Boom Calculations

Symbols used in sonic boom calculations are presented in Table A-3. The basic equations, obtained from Reference (a), used to evaluate the shock wave (sonic boom) overpressure, i.e. the pressure over and above atmospheric and sound intensity are simply:

$$\Delta p_{max} = K_p K_R \sqrt{p_v p_g}(M^2 - 1)^{1/8} h_e^{-3/4} l^{3/4} K_S \quad \text{and} \quad I = 20\log_{10}\left(\frac{\Delta p_{max}}{p_{Ref}}\right)$$

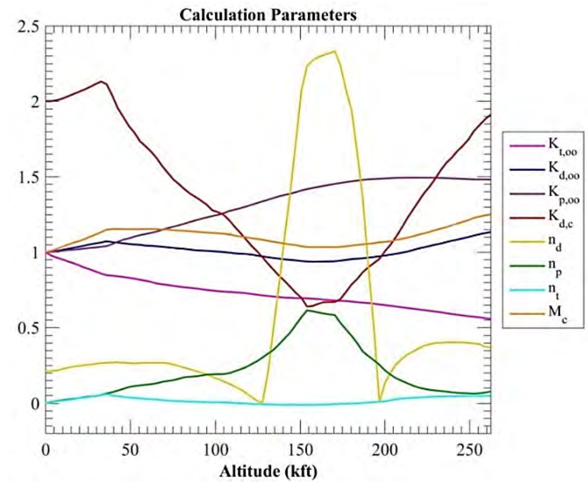
To evaluate this, we start by defining the vehicle's effective Mach number:

$$M_e = \sqrt{1 + \frac{[A(1 - B\tan\gamma)]^2}{[A(\tan\gamma + B]^2 + (C \cdot D)^2}}$$

where

$$A = \frac{1}{\cos\gamma\sqrt{M^2-1}}, \quad B = \frac{1}{\cos\theta\sqrt{M^2-1}}, \quad C = \frac{\tan\theta}{\sqrt{M^2-1}}$$

$$\text{and} \quad D = \tan^2\gamma + 1$$



We then evaluate the following three parameters whose arguments may be found from the graphic shown at the right. Alternatively, a series of functions were written to calculate these.

$$K_d = K_{d,c} + (K_{d,\infty} - K_{d,c})\left(\frac{M_e - M_c}{M_e - 1}\right)^{n_d}$$

$$K_p = K_{p,\infty}\left(\frac{M_e - 1}{M_e - M_c}\right)^{n_p}$$

$$K_t = K_{t,\infty}\left(\frac{M}{M - 1}\right)^{n_t}$$

Given the above, we can now calculate the following:

$$d = K_d\left(\frac{h_v - h_g}{\sqrt{M_e^2 - 1}}\right) \quad \text{and} \quad \tan\phi = \frac{\mathrm{D} \cdot \tan\theta\cos\gamma}{\tan\gamma + B}$$

$$d_x = d\cos\phi \quad \text{and} \quad d_y = d\sin\phi$$

$$h_e = \sqrt{d_y^2 + \left((h_v - h_g)\cos\gamma + d_x\sin\gamma\right)^2}$$

The next steps are to calculate the shape factor K_S. To do this, start with defining the lift parameter:

$$K_L = \frac{\sqrt{M^2 - 1}\, W\cos\gamma\cos\theta}{1.4 p_v M^2 l^2}$$

Next, we calculate the total effective area of the vehicle:

$$A_e(x) = A(x) + B(x)$$

where A(x) is the cross section area normal to the vehicle and B(x) is defined as

$$B(x) = K_L \int_0^x b(x)dx$$

where B(x) is the vehicle span as a function of length. Given the functional forms for A(x) and B(x), one then seeks the value

$$x = l_e \text{ such that } A_e(x = l_e) \text{ is a maximum defined to be } A_{e,max}$$

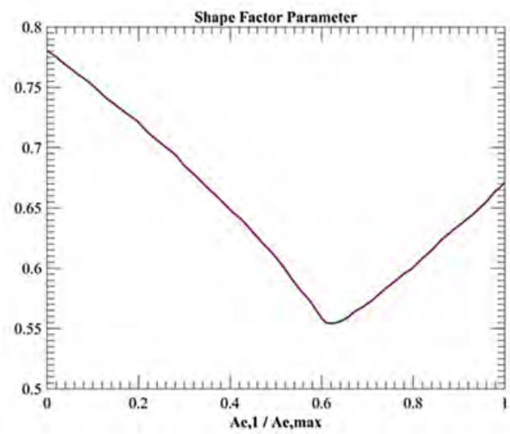
We then define

$$A_{e,1} = A_e(\tfrac{1}{2}l_e).$$

At this point, we are armed with enough to finally calculate the shape factor with the aid of the graphic at the right.

The value for K_S as well as K_P and h_e may now be substituted into the original equation for Δp. Note that the value for the reflection coefficient, K_R is nearly always set to 2.

$$\frac{K_S}{\left(\frac{\sqrt{A_{e,max}}}{l^{3/4} l_e^{1/4}}\right)}$$



Lastly, in addition to Δp, the duration of the shockwave may also be calculated via the following:

$$\Delta t = K_t \frac{3.42}{a_v} \frac{M}{(M^2 - 1)^{3/8}} h_e^{1/4} l^{3/4} K_S$$

A3.2 Stage Impact Calculations

The acoustic impact of FE-2 flight test rocket motor on the marine environment was also determined. Note that the methodology used here is derived from the methodology used in Reference (b), the Overseas Environmental Assessment for D5 Pacific Missile Testing (August 2004) which determined the acoustic impact for stage drops of the D5 missile.

The proposed flight test uses Polaris A3 1st and 2nd stage motor with an Orbus 1A 3rd stage motor. The 1st stage motor is 182" long with a diameter of 54". There is an additional modified A3 interstage section that is 34.3" long with a diameter of 54". The 2nd stage motor is 89" long with a diameter of 54" and the 3rd stage motor is 52" long with a 54" diameter. The nose fairing and shroud is approximately 123" long composed of a constant 54" diameter for 24" of length and a conic section with a base diameter of 54" tapering to a 4" diameter at the nose for the remaining length.

Table A-3
List of Symbols Used in Sonic Boom Calculations

Symbol	Definition
A(x)	area of aircraft cross sections normal to flight direction at a given value of x-coordinate (cross sections normal to longitudinal axis of aircraft may be substituted in most cases), m^2
$A_e(x)$	total effective area of aircraft at a given value of x-coordinate, A(x) + B(x), m^2
$A_{e,\ max}$	maximum effective area, m^2
$A_{e,\ 1}$	total effective area at midpoint of effective aircraft length, l_e, m^2
a_v	speed of sound at aircraft (vehicle) altitude, m/sec
B(x)	equivalent cross-sectional area due to lift at a given value of x-coordinate, m^2
B_{max}	maximum equivalent cross-sectional area due to lift, m^2
b(x)	local span of aircraft planform at a given value of x-coordinate, m
d	distance between aircraft ground-track position at time of sonic-boom generation and location of ground impact point, km
d_x	component of d in direction of aircraft ground track, km
d_y	component of d in direction perpendicular to aircraft ground track (i.e. in lateral direction), km
$d_{y,\ c}$	value of d_y at lateral limit or cutoff of sonic-boom ground footprint, km
h	altitude of aircraft above ground, h_y - h_g, km
h_e	effective altitude, km
h_g	altitude of ground above sea level, km
h_v	altitude of aircraft (vehicle) above sea level, km
K_d	ray-path distance factor
$K_{d,\ c}$	ray-path distance factor for cutoff conditions, $M_e = M_c$
$K_{d,\ \infty}$	ray-path distance factor for an infinite Mach number
K_L	lift parameter
K_p	pressure amplification factor
$K_{p,\ \infty}$	pressure amplification factor for an infinite Mach number
K_R	reflection factor, assumed to be 2.0
K_S	aircraft shape factor
K_t	signature duration factor
$K_{t,\ \infty}$	signature duration factor for an infinite Mach number
l	aircraft characteristic length, normally the fuselage length, m
l_e	effective length of aircraft used in determination of aircraft shape factor, m
M	aircraft Mach number
M_c	aircraft cutoff Mach number below which sonic boom will not reach ground
M_e	aircraft effective Mach number governing sonic-boom atmosphere propagation characteristics
n_d	exponent of Mach number parameter in atmospheric distance factor curve fit
n_p	exponent of Mach number parameter in atmospheric pressure amplification factor curve fit
n_t	exponent of Mach number parameter in atmospheric signature duration factor curve fit
p	atmospheric pressure, Pa
Δp	incremental pressure due to sonic boom, Pa

Maximum contact areas for the stages are as follows:

1st stage: 81.12 ft^2
2nd stage: 33.38 ft^2
3rd stage: 19.5 ft^2
Nose fairing: 55.14 ft^2

Note that the "Nose Fairing" cited directly above is actually comprised of an original nose fairing with two additional skin extensions at the base resulting in three separate pieces upon jettison. However, for the sake of this analysis, it was conservatively assumed that the fairing plus the two skin extensions would jettison, fall, and impact as a single unit resulting in a higher calculated impact disturbance.

The position, velocity, and frontal area of the stages was used along with the coefficient of drag to calculate the ballistic trajectory to determine impact velocity and position. The ballistic path was calculated for two values of drag coefficient, $C_D = 1$ and $C_D = 3$. A drag coefficient of 1 was considered conservative as it would result in a higher impact velocity, and therefore, a higher kinetic energy at impact. A drag coefficient of 3 was considered more typical for the analysis of a tumbling cylinder.

After determining the impact kinetic energy, a common standard used in the D5 OEA was applied that states 1% of the source kinetic energy is converted to radiated acoustic energy at impact. It was further assumed that the impact signature of the bodies was equivalent to the impact signature characteristics of the equivalent D5 stages. Using these assumptions and Table B-1 presented in the D5 OEA report, a direct empirical equation can be determined between acoustic energy and maximum 1/3rd octave band decibel level referenced to 1 micro Pascal squared second.

The following logarithmic equation fits the data with $R^2 = 1$:

$$dB\ re\ 1\mu Pa^2 - s \cong 4.3512 * \ln\left(\frac{E_{AC}}{10^4}\right) + 204.26 \qquad \text{A.1}$$

where E_{AC} is the radiated acoustic energy in Joules and the maximum 1/3rd octave band decibel level is referenced to 1 micro Pascal squared second.

This equation allows for the calculation of the source decibel level at impact. Table A-4 below presents values for source dB for the major ocean impact events along the trajectory.

Table A-4
Pressure Values for Source dB for Ocean Impact Events in the BOA.

Impact Event	Source dB Value (1 μPa^2-s)	
	$C_D = 1$	$C_D = 3$
1st Stage	217.70	212.53
2nd Stage	205.12	200.26
Nose fairing	196.35	191.54
3rd Stage	200.73	195.91

To determine the affected zones of influence for various threshold levels, a further equation for the attenuation of the signal through the environment must be used. Conservatively assuming a linear attenuation model for signal propagation, the zone of influence (ZOI) for a source dB_{source} at threshold value dB_{thresh} is given by the following:

$$ZOI = r_{shock} * 10^{\left(\frac{dB_{source} - 20*\log\left(\frac{r_{shock}}{r_0}\right) - dB_{thresh}}{20}\right)} \quad \text{A.2}$$

where r_0 = 1 meter and $r_{shock} \approx$ 32.51 meters for sea water near the surface at 20°C. The ZOI is a common value used in environmental assessments to determine effects on marine life in the affected areas for various decibel threshold values. An example of these calculations carried out for the first stage is presented below.

First Stage Calculation Example. Given an initial state vector, the impact velocity for the first stage with a drag coefficient assumption of C_D = 1 was calculated to be: v_{imp} = 152.39 m/s. Therefore, the kinetic energy at impact with a mass of 1890.35 kg is given by:

$$KE_{imp} = \frac{1}{2} m v_{imp}^2 = \frac{1}{2} * 1890.35kg * \left(152.39\frac{m}{s}\right)^2 = 2.195 * 10^7\, Joules \quad \text{A.3}$$

From the D5 OEA report, a common standard for the conversion of source kinetic energy to radiated acoustic energy (E_{AC}) is applied.

$$E_{AC} = 0.01 * KE_{imp} = 2.195 * 10^5\, Joules \quad \text{A.4}$$

Using the empirical relationship to convert acoustic energy to source dB values results in the following:

$$dB_{source} = 4.3512 * \ln\left(\frac{2.195E5}{10^4}\right) + 204.26 \quad \text{A.5}$$

$dB_{source} = 217.70\ dB\ re\ 1\mu Pa^2 - s$ (decibel value relative to one micro Pascal squared second)
Finally, with the dB_{source} value determined, a zone of influence (ZOI) can be calculated for various threshold dB values (dB_{thresh}) using Equation A.2.

Assuming a dB_{thresh} = 182 dB, and using standard values for sea conditions at surface level, the ZOI for a 217.7 dB source can be found:

$$ZOI = 32.51 * 10^{\left(\frac{217.7 - 20*\log(32.51) - 182}{20}\right)} \cong 60.95m$$

Hence, a 217.7 dB source would result in a 61m radius around the impact location with dB values greater than the 182 dB threshold. Similar calculations can be carried out to determine ZOI radii and affected area/volume for any required threshold value. The affected surface area or volume can be used in conjunction with observations of marine life density in a given location to estimate impact on species for any discrete acoustic event.

A3.3 Frequency Spectrums

Sonic boom frequency composition is plotted in Figure A-3 and the approximate power spectrum for stage impacts is shown in Figure A-4.

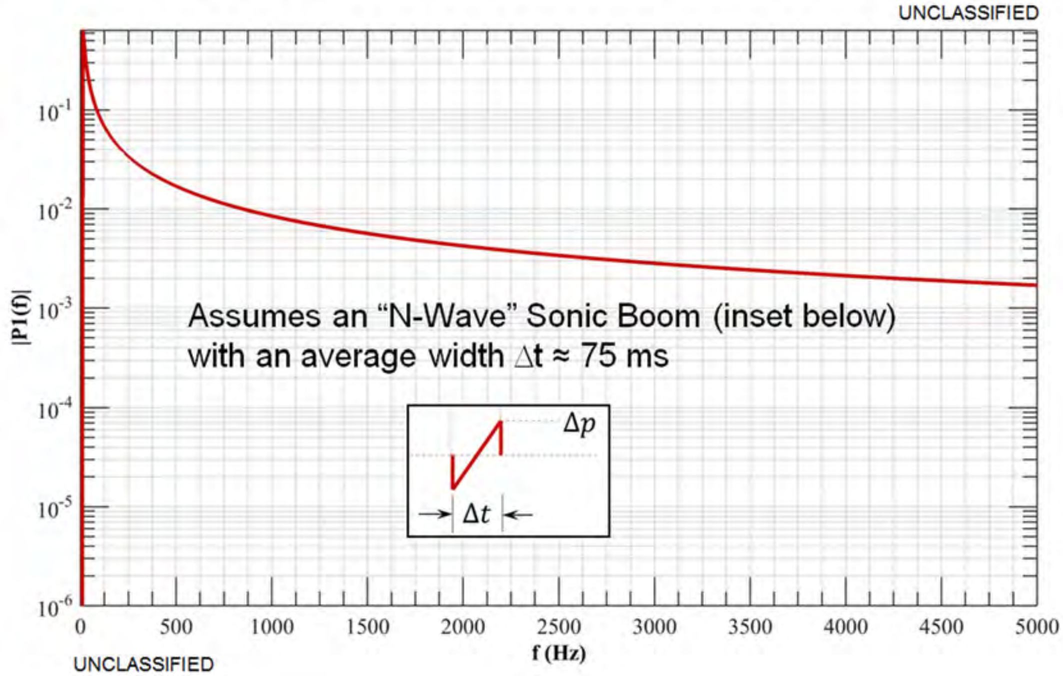


Figure A-3. Power Spectrum of Sonic Boom Assuming a 75 ms Duration.

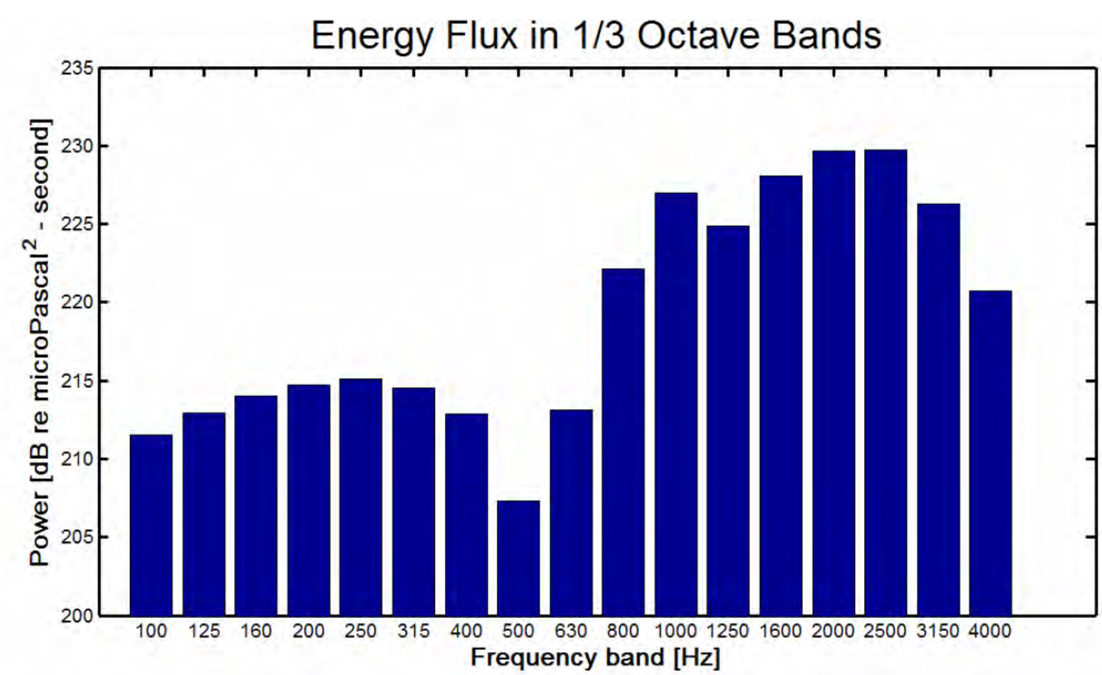


Figure A-4. Approximate Power Spectrum of Stage Impacts.