BIOLOGICAL ASSESSMENT

Flight Experiment 1

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and

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TABLE OF CONTENTS

1.0 EXECU	FIVE SUMMARY	1
2.0 INTROE	UCTION	6
2.1 Purpos	se and Objectives	6
2.2 Regula	atory Setting	6
3.0 DESCRI	PTION OF THE ACTION AREA & PROPOSED ACTION	8
3.1 Descri	ption of the Action Area	8
3.2 Descri	puon of the Proposed Action	9
$3.2.1 L_{0}$	$r_{\rm Elight}$ Description in the POA and at USAC VA	
3.2.2 FI	e-Flight Freparations in the BOA and at USAO-KA	12
3.2.3 M	set flight Operations	
2.2 Envir	instantial Strangeorg Associated with the Droposed Astion	14
3.3 Environ	annental Suessors Associated with the Proposed Action	13
3320	rect Contact	15
3.3.2 D	assal Strika	15
3.3.5 V	resure to Hererdous Chamicale	10
3.3.4 E	sposure to Hazardous Chemicals	10
5.5.5 D	tion Measures	1/
3.4 Mitiga	tion measures	
4.0 LISTED	Mammals	
4.1.1	Minke whale (<i>Balaenoptera acutorostrata</i>)	
412	Sei whale (Balaenontera horealis)	25
413	Bryde's whale (<i>Balaenoptera eden</i> i)	26
414	Blyde's whate (Balaenoptera eucen)	26
415	Fin whale (Balaenoptera physalus)	27
416	Short-beaked common dolphin (<i>Delphinus delphis</i>)	28
4.1.0	Pygmy killer whole (Forosa attornata)	
4.1.7	Short finned pilot whole (Clobicaphala maarorhymohue)	
4.1.8	Pisso's dolphin (Grampus ariseus)	
4.1.9	Longmon's backed whole (Indongastus nasificus)	
4.1.10	Durginan's beaked whate (<i>Indopacetus pacificus</i>)	
4.1.11	Pygny sperm whale (<i>Kogia breviceps</i>)	
4.1.12	Dwart sperm whale (<i>Kogia sima</i>)	
4.1.13	Fraser's dolphin (<i>Lagenodelphis hosei</i>)	
4.1.14	Humpback whale (<i>Megaptera novaeangliae</i>)	
4.1.15	Blainville's beaked whale (<i>Mesoplodon densirostris</i>)	
4.1.16	Killer whale (Orcinus orca)	
4.1.17	Melon-headed whale (<i>Peponocephala electra</i>)	
4.1.18	Sperm whale (<i>Physeter macrocephalus</i>)	
4.1.19	False killer whale (<i>Pseudorca crassidens</i>)	40
4.1.20	Pantropical spotted dolphin (Stenella attenuata)	41
4.1.21	Striped dolphin (Stenella coeruleoalba)	
4.1.22	Spinner dolphin (Stenella longirostris)	43
4.1.23	Rough-toothed dolphin (Steno bredanensis)	43
4.1.24	Bottlenose dolphin (Tursiops truncatus)	45

4.1.25 Cuvier's beaked whale (<i>Ziphius cavirostris</i>)	
4.1.26 Hawaiian monk seal (Neomonachus schauinslandi)	
4.2 Birds	47
4.2.1 Newell's shearwater / `A`o (<i>Puffinus auricularis newelli</i>)	
4.3 Sea Turtles	
4.3.1 Loggerhead turtle (<i>Caretta caretta</i>)	
4.3.2 Green turtle (<i>Chelonia mydas</i>)	
4.3.3 Leatherback turtle (<i>Dermochelys coriacea</i>)	
4.3.4 Hawksbill turtle (<i>Eretmochelys imbricata</i>)	
4.3.5 Olive ridley turtle (<i>Lepidochelys olivacea</i>)	
4.4 Fish	
4.4.1 Bigeye Thresher Shark (<i>Alopias superciliosus</i>)	
4.4.2 Oceanic Whitetip Shark (<i>Carcharhinus longimanus</i>)	
4.4.3 Humphead Wrasse (Cheilinus undulatus)	
4.4.4 Reef Manta Ray (Manta alfredi)	
4.4.5 Oceanic Giant Manta Ray (Manta birostris)	
4.4.6 Scalloped hammerhead (Sphyrna lewini)	
4.4.7 Pacific Bluefin Tuna (Thunnus orientalis)	65
4.5 Corals (Phylum Cnidaria)	
4.5.1 Acanthastrea brevis	
4.5.2 Acropora aculeus	
4.5.3 Acropora aspera	72
4.5.4 Acropora dendrum	
4.5.5 Acropora listeri	
4.5.6 Acropora microclados	74
4.5.7 Acropora polystoma	74
4.5.8 Acropora speciosa	75
4.5.9 Acropora tenella	76
4.5.10 Acropora vaughani	76
4.5.11 Alveopora verrilliana	77
4.5.12 Cyphastrea agassizi	
4.5.13 Heliopora coerulea	
4.5.14 Leptoseris incrustans	
4.5.15 Montipora caliculata	
4.5.16 Pavona cactus	
4.5.17 Pavona venosa	
4.5.18 Turbinaria reniformis	
4.5.19 Turbinaria stellulata	
4.6 Mollusks (Phylum Mollusca)	
4.6.1 Pinctada margaritifera	
4.6.2 Trochus niloticus	
5.0 EFFECTS OF THE ACTION	
5.1 Stressors	
5.1.1 Exposure to Elevated Sound Levels	
5.1.2 Direct Contact	

5.1.3 Vessel Strike	116
5.1.4 Exposure to Hazardous Chemicals	118
5.1.5 Disturbance from Human Activities and Equipment Operation	122
6.0 CUMULATIVE EFFECTS	126
6.1 Foreseeable Future Actions and Environmental Considerations	126
6.1.1 Commercial and Recreational Fishing	126
6.1.2 Subsistence and Artisanal Fishing	127
6.1.3 Vessel Traffic	127
6.1.4 Ocean Pollution	128
6.1.4 Climate Change and Ocean Acidification	128
6.2 Cumulative Effects on Listed Resources	130
6.2.1 Cumulative Effects on Marine Mammals	130
6.2.2 Cumulative Effects on Birds	131
6.2.3 Cumulative Effects on Sea Turtles	132
6.2.4 Cumulative Effects on Fish	133
6.2.5 Cumulative Effects to Corals and Mollusks	134
6.3 Cumulative Effects related to Climate Change and Ozone Depletion	136
7.0 CONCLUSIONS	137
8.0 LITERATURE CITED	140
9.0 LIST OF PREPARERS	155
APPENDIX A: ANALYSIS OF FE-1 SONIC-BOOM AND STAGE DROP ACOUSTICS	156
A1 Introduction	156
A2 Methodology	157
A2.1 Sonic Boom	157
A2.2 Stage Impact	158
A3 Results	159
A3.1 Sonic Boom Calculations	160
A3.2 Stage Impact Calculations	163
A3.3 Frequency Spectrums	165

LIST OF TABLES

Table 1-1. Effect Determinations for Species Requiring Consultation in the Action Area
Table 3-1. Launch Vehicle Characteristics 11
Table 3-2. Payload System Characteristics 12
Table 4-1. Species Requiring Consultation [‡] in the Action Area 20
Table 4-2. Marine Mammal Presence in the Broad Ocean Area (BOA) and near Illeginni Islet23
Table 4-3. Documented Occurrences of Spinner Dolphins at USAG-KA
Table 4-4. Sea Turtle Presence in the Broad Ocean Area (BOA) and Near Illeginni Islet
Table 4-5. Fish Presence in the Broad Ocean Area (BOA) and Near Illeginni Islet, Kwajalein
Atoll
Table 4-6. Number of Survey Sites (2008 to present) with Observed UES Fish Consultation
Species and Occurrences at USAG-KA
Table 4-7. Number of Survey Sites (2008 to present) with Observed Coral Consultation Species
Occurrences at USAG-KA
Table 4-8. Number of Survey Sites (2008 to present) with Observed Mollusk Consultation Species
Occurrences at USAG-KA
Table 5-1. Estimated Sonic Boom Peak Sound Pressure Levels in Water for FE-1 Trajectory 88
Table 5-2. Estimated Stage Impact Contact Areas and Peak Sound Pressure Levels for FE-1
Vehicle Components
Table 5-3. Marine Mammal Species Groups for Assessing the Effects of Elevated Sound Pressure
Levels
Table 5-4. Acoustic Thresholds for PTS, TTS, and behavioral disruption from Single Exposure to
Impulsive In-Water Sounds in Marine Mammals
Table 5-5. Acoustic Thresholds for Physical Injury and Behavioral Disruption in Sea Turtles94
Table 5-6. Acoustic Thresholds for Physical Injury and Behavioral Disruption in Fish. 95
Table 5-7. Maximum Underwater Radial Distances and Acoustic Affect Areas for Marine
Mammals, Sea Turtles, and Fish from FE-1 Component Splashdowns in the BOA
Table 5-8. Estimated Radial Distances and Acoustic Affect Areas for Marine Mammals, Sea
Turtles, and Fish from Payload Impact at Illeginni Islet
Table 5-9. Number of Marine Mammal and Sea Turtle Exposures to Acoustic Impacts from FE-1
Launch Vehicle Component Splashdown in the BOA100
Table 5-10. Estimated Number of Sea Turtle Exposures to Elevated Sound Pressure Levels for
Payload impact and Sonic Boom at Illeginni Islet
Table 5-11. Variables Used in Direct Contact Probability Calculations. 106
Table 5-12. Probability of Direct Contact from FE-1 Vehicle Components and Estimated Number
of Marine Mammal and Sea Turtle Exposures in the BOA
Table 5-13. Estimated Numbers of Consultation Coral Colonies and Individual Mollusks in
Affected Habitats
Table 6-1. Future Actions and Other Environmental Considerations Identified for Cumulative
Effects Analysis
Table 7-1. Effect Determinations for Species Requiring Consultation in the Action Area
Table A-1. Sonic Boom Intensity in Water at Various Reference Locations 159
Table A-2. Tabular values of Affected Area. 160
Table A-3. List of Symbols Used in Sonic Boom Calculations 162
Table A-4. Pressure values for source dB for ocean impact events in the BOA164

LIST OF FIGURES

Figure 3-1. Flight Experiment 1 (FE-1) Representative Flight Path (curved yellow line) and	
Sensors.	8
Figure 3-2. Representative Drop Zones (yellow circles) for spent motors and nose fairing	
assembly	9
Figure 3-3. Notional Impact Area at Illeginni Islet, Kwajalein Atoll.	10
Figure 3-4. Potential Land Impact Area on Illeginni Islet, Kwajalein Atoll	10
Figure 3-5. Typical Strategic Target System (STARS) Vehicle	11
Figure 3-6. Notional Locations of Precision Scoring Augmentation Rafts	13
Figure 5-1Representative Maximum Direct Contact Affect Areas for a Shoreline Payload Impa	act
at Illeginni Islet, Kwajalein Atoll1	13
Figure A-1: Sonic Boom Illustration1	56
Figure A-2. Plot of Area Affected vs. sound intensity for the Sonic Boom and Stage Impacts1	59
Figure A-3. Power spectrum of sonic boom assuming a 75 ms duration1	66
Figure A-4. Approximate Power spectrum of stage impacts	66

LIST OF ACRONYMS AND ABREVIATIONS

Acronym or A	bbreviation
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Full Phrase

μΡα	micro-Pascal
Al_2O_3	alumina
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
EA	Environmental Assessment
EIS	Environmental Impact Statement
ESA	Endangered Species Act
FAO	Food and Agriculture Organization of the United Nations
FE-1	Flight Experiment 1
ft	feet
ft^2	square feet
ft^3	cubic feet
FONSI	Finding of No Significant Impact
FTS	Flight Termination System
HCl	hydrochloric acid
HE	High Explosives
Hz	Hertz
in	inch
KEEP	Kwajalejn Environmental Emergency Management Plan
ko	kilogram
kHz	kilohertz
km	kilometer
km^2	square kilometer
KMISS	Kwajalejn Missile Impact Scoring System
KMRSS	Kwajalein Missile Impact Scotling System
KINKSS	Kauai Test Facility
lb	nound
	Landing Craft Utility
m and a second s	mator
m^2	illeter
111 m ³	square meter
	Cubic Indicis Mobile April Target Support System
MAISS mi	mile Aeria Target Support System
mi ²	nint square mile
	square nine Marshall Islanda Marina Dasouraa Authority
	Minutemen III
	Manine Manuel Dustastian Ast
WINIPA	Marine Mammal Protection Act
ms	minisecond
nm	nautical mile
NMFS	National Marine Fisheries Service
NWHI	Northwestern Hawaiian Islands

Acronym or Abbreviation	Full Phrase
PIRATES	Portable Instrumented Range Augmentation Telemetry Equipment System
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
RV	Reentry Vehicle
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
USMV	United States Motor Vessel
W	Tungsten

1.0 EXECUTIVE SUMMARY

The Proposed Action, Flight Experiment 1 (FE-1), is sponsored by the Office of the Under Secretary of Defense for Acquisition, Technology and Logistics, which has designated the Department of the Navy (US Navy) Strategic Systems Programs (SSP) as the lead agency and action proponent of the Proposed Action. The US Navy, and the US Army Space and Missile Defense Command/Army Strategic Forces Command (USASMDC/ARSTRAT) have prepared this biological assessment (BA) to determine the extent to which a single flight test of the FE-1 and associated activities may affect species requiring consultation.

The US Navy proposes to conduct a single flight test to prove various aspects of the Navy FE-1 system's capabilities including flight testing of a developmental payload. The purpose of the Proposed Action is to collect data on a developmental payload by testing range performance and to demonstrate capabilities as a prospective means to strike capabilities. Specifically, the FE-1 experiment would develop, integrate, and flight test the developmental payload concept to demonstrate the maturity of key technologies. These technologies include precision navigation, guidance and control, and enabling capabilities. The developmental payload would be launched from Kauai Test Facility (KTF) located on the Pacific Missile Range Facility (PMRF) in Hawai'i and would travel across a broad ocean area (BOA) of the Pacific Ocean towards the Ronald Reagan Ballistic Missile Defense Test Site (Reagan Test Site [RTS]) at the US Army Garrison-Kwajalein Atoll (USAG-KA), formerly known as US Army Kwajalein Atoll (USAKA), in the Republic of the Marshall Islands (RMI). The terminal end of the missile flight test would be at Illeginni Islet in Kwajalein Atoll.

The need for the Proposed Action is to provide flight test data and information required by the DoD to provide a basis for ground testing, modeling, and simulation of developmental payload performance applicable to a range of possible FE-1 concepts being studied as a way to inform potential future strike capability determinations.

The Compact of Free Association between the RMI and the US (48 US Code [USC], § 1921) requires all US government activities at USAG-KA and all USAG-KA 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). The UES require 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 do 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.

The Action Area for this BA is as follows:

- The over-ocean flight corridor in the BOA of the central Pacific ocean;
- Spent rocket motor drop zones in the BOA; and
- The terminal end of the flight test, which consists of the payload flight and its impact at Illeginni Islet.

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

Section 3 of this BA expands on the definition of the Action Area, describes the background of the FE-1 program, and presents a detailed description of the Proposed Action, a single FE-1 flight test. Section 3 also includes information about the environmental stressors associated with the Proposed Action as well as associated mitigation measures.

Section 4 introduces the species requiring consultation that will potentially be affected by the action: 25 cetacean, 1 phocid, 1 bird, 5 sea turtle, 7 fish, 19 coral, and 2 mollusk species (Table 4-1). A brief description of each species, including its distribution, population status, habitat preferences, threats, and hearing ability, is provided.

No designated critical habitat for any of the species evaluated in this BA is present in the Action Area.

Section 5, Effects of the Proposed Action, describes the potential stressors that will be associated with the Proposed Action: exposure to elevated sound levels, direct contact with falling FE-1 components, strike by vessels used for monitoring and recovery operations, exposure to hazardous chemicals, and disturbance from human activities and equipment operation. The direct and indirect effects on consultation species are analyzed and discussed for the parts of the Action Area: (a) the BOA and (b) the vicinity of Illeginni Islet. For each stressor in each part of the Action Area, an effect determination is presented for each group of species. Under the ESA, actions may have no effect, 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.

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

Section 7, Conclusions, summarizes the effects of the Action on consultation species. This section also includes conclusions for effect determinations and population level context for marine mammals, birds, sea turtles, fish, corals and mollusks.

Based on analyses of all of the potential stressors in the Action Area, a "may affect but not likely to adversely affect" determination was concluded for all 24 species of cetaceans, Hawaiian monk seals, Newell's shearwaters, sea turtles in the water, 3 species of sharks, 2 species of manta rays, and Pacific bluefin tuna (Table 1-1). These species have low densities and patchy distributions in the Action Area and the probability of a cetacean, sea turtle or these fish being in a FE-1 related area of injury, death, or harassment is considered extremely remote. In addition, the FE-1flight test is a single event and the likelihood of adverse effects is considered to be discountable. Based on this, the determination is that the flight tests may affect but are not likely to adversely affect these organisms.

It is possible that a relatively small and undeterminable number of fish, coral, or mollusk larvae are likely to 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 discountable.

A "may affect and likely to adversely affect" determination was concluded for sea turtle nesting (2 species), non-larval humphead wrasses, 14 species of corals, and 2 mollusk species near Illeginni Islet (Table 1-1). Although coral reefs are never intentionally targeted, it is possible that the payload impact could occur at the shoreline. Mortality or injury could occur from impact by ejecta and debris outward to 91 meters (m; 300 feet [ft]), and breakage and toppling of corals due to substrate vibration may occur outward to 37.5 m (122.9 ft) from the point of impact. These effects are expected to decrease with

increasing distance. The effects of elevated sound pressure levels would not affect marine invertebrates and would likely have no long-term effects on sea turtles and fish. In addition, post-test recovery and cleanup activities on land and in shallow waters may adversely affect sea turtle nesting habitat as well as nearshore reef flat marine life including fish, corals, and mollusks. Estimates of these effects were made based on conservative assumptions which likely lead to overestimates of effects and these effects are expected to be reduced by implementation of mitigation measures. The National Marine Fisheries Service (NMFS) and US Fish and Wildlife Service (USFWS) would be asked to provide guidance and/or assistance during shallow water recovery and cleanup at Illeginni Islet. In all cases, recovery and cleanup operations would be conducted in a manner to avoid or minimize potential harm to biological resources.

Table 1-1
Effect Determinations for Species Requiring Consultation‡ in the Action Area
("-"=not known to be present in effect area, o=may affect but not likely to adversely affect, •=likely to
adversely affect).

				BOA	L		Vicinity of Illeginni Islet						
Scientific Name	Common Name	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	0	0	0	0	0	0	-	0	-	0		
B. borealis	Sei whale	0	0	0	0	0	-	-	-	-	-		
B. edeni	Bryde's whale	0	0	0	0	0	0	-	0	-	0		
B. musculus	Blue whale	0	0	0	0	0	-	-	-	-	-		
B. physalus	Fin whale	0	0	0	0	0	-	-	-	-	-		
Delphinus delphis	Short-beaked common dolphin	-	-	-	-	-	0	-	0	-	0		
Feresa attenuata	Pygmy killer whale	0	0	0	0	0	-	-	-	-	-		
Globicephala macrorhynchus	Short-finned pilot whale	0	0	0	0	0	0	-	0	-	0		
Grampus griseus	Risso's dolphin	0	0	0	0	0	-	-	-	-	-		
Indopacetus pacificus	Longman's beaked whale	0	0	0	0	0	-	-	-	-	-		
Kogia breviceps	Pygmy sperm whale	0	0	0	0	0	-	-	-	-	-		
K. sima	Dwarf sperm whale	0	0	0	0	0	-	-	-	-	-		
Lagenodelphis hosei	Fraser's dolphin	0	0	0	0	0	-	-	-	-	-		
Megaptera novaeangliae	Humpback whale	0	0	0	0	0	-	-	-	-	-		
Mesoplodon densirostris	Blainville's beaked whale	0	0	0	0	0	-	-	-	-	-		
Orcinus orca	Killer whale	0	0	0	0	0	0	-	0	-	0		
Peponocephala electra	Melon-headed whale	0	0	0	0	0	0	-	0	-	0		
Physeter macrocephalus	Sperm whale	0	0	0	0	0	0	-	0	-	0		
Pseudorca crassidens	False killer whale	0	0	0	0	0	-	-	-	-	-		
Stenella attenuata	Pantropical spotted dolphin	0	0	0	0	0	0	-	0	-	0		
S. coeruleoalba	Striped dolphin	0	0	0	0	0	0	-	0	-	0		
S. longirostris	Spinner dolphin	0	0	0	0	0	0	-	0	-	0		
Steno bredanensis	Rough-toothed dolphin	0	0	0	0	0	-	-	-	-	-		
Tursiops truncatus	Bottlenose dolphin	0	0	0	0	0	0	-	0	-	0		
Ziphius cavirostris	Cuvier's beaked whale	0	0	0	0	0	-	-	-	-			

				BOA			Vicinity of Illeginni Islet						
	Common Namo	llevated ound	Direct	'essel trike	Hazard. Chem.	Human Disturb.	llevated	Direct	rike	Hazard. Them.	Human Disturb.		
Scientific Name	Common Name	чv	ц 0	> s	ЦО	ЦЦ	цs		≥ s	ЦС			
Phocids													
Neomonachus schauinslandi	Hawaiian monk seal	0	0	0	0	0	-	-	-	-	-		
Birds													
Puffinus auricularis newelli	Newell's shearwater	0	0	0	0	0	-	-	-	-	-		
Sea Turtles													
Caretta caretta	Loggerhead turtle	0	0	0	0	0	-	-	-	-	-		
Chelonia mydas	Green turtle	0	0	0	0	0	0	•	0	•	•		
Dermochelys coriacea	Leatherback turtle	0	0	0	0	0	-	-	-	-	-		
Eretmochelys imbricata	Hawksbill turtle	0	0	0	0	0	0	٠	0	•	•		
Lepidochelys olivacea	Olive ridley turtle	0	0	0	0	0	-	-	-	-	-		
Fish (non-larval)													
Alopias superciliosus	Bigeye thresher shark	0	0	0	0	0	-	-	-	-	-		
Carcharhinus longimanus	Oceanic whitetip shark	0	0	0	0	0	-	-	-	-	-		
Cheilinus undulatus	Humphead wrasse	-	-	-	-	-	0	٠	0	0	•		
Manta alfredi	Reef manta ray	-	-	-	-	-	0	0	0	0	0		
M. birostris	Oceanic giant manta ray	0	0	0	0	0	-	-	-	-	-		
Sphyrna lewini	Scalloped hammerhead	-	-	-	-	-	0	-	0	-	0		
Thunnus orientalis	Pacific bluefin tuna	0	0	0	0	0	-	-	-	-	-		
Corals (non-larval)													
Acanthastrea brevis		-	-	-	-	-	0	•	0	0	•		
Acropora aculeus		-	-	-	-	-	0	•	0	0	•		
A. aspera		-	-	-	-	-	0	٠	0	0	•		
A. dendrum		-	-	-	-	-	0	٠	0	0	•		
A. listeri		-	-	-	-	-	0	٠	0	0	•		
A. microclados		-	-	-	-	-	0	٠	0	0	•		
A. polystoma		-	-	-	-	-	0	٠	0	0	•		
A. speciosa		-	-	-	-	-	0	0	0	0	0		
A. tenella		-	-	-	-	-	0	0	0	0	0		
A. vaughani		-	-	-	-	-	0	0	0	0	0		
Alveopora verilliana		-	-	-	-	-	0	٠	0	0	•		
Cyphastrea agassizi		-	-	-	-	-	0	•	0	0	•		
Heliopora coerulea		-	-	-	-	-	0	•	0	0	•		
Leptoseris incrustans		-	-	-	-	-	0	0	0	0	0		
Montipora caliculata		-	-	-	-	-	0	•	0	0	•		
Pavona cactus		-	-	-	-	-	0	0	0	0	0		
P. venosa		-	-	-	-	-	0	•	0	0	•		

			BOA							Vicinity of Illeginni Islet						
Scientific Name	Common Name	Elevated	Sound	Direct	Vessel	Strike	Hazard. Chem	Human	Disturb.	Elevated Sound	Direct	Vessel Cessel	Hazard. Chem.	Human Disturb.		
Turbinaria reniformis			-	-		-	-		-	0	٠	0	0	•		
T. stellulata			-	-		-	-		-	0	٠	0	0	•		
Mollusks (non-larval)																
Pinctada margaritifera	Black-lipped pearl oyster		-	-		-	-	-	-	0	0	0	0	0		
Trochus niloticus ⁵	Top shell snail		-	-		-	-		-	0	٠	0	0	•		
Larval Fish, Coral, and Mollusks		(0	0		0	0	C)	0	0	0	0	0		

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 1 (FE-1) 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 intends to carry out the action described in section 2.0 below, in accordance with sections 5013 and 5062 of Title 10, United States Code (USC).

The Proposed Action involves conducting a FE-1 flight test to collect data on a developmental payload. This FE-1 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 the US Army Garrison-Kwajalein Atoll (USAG-KA) 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, 2 mollusks, and 19 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 purpose of the Proposed Action is to collect data on a developmental payload by testing range performance and to demonstrate capabilities as a prospective means to strike capabilities. Specifically, the FE-1 experiment would develop, integrate, and flight test the developmental payload concept to demonstrate the maturity of key technologies. These technologies include precision navigation, guidance and control, and enabling capabilities. The need for the Proposed Action is to provide flight test data and information required by the DoD to provide a basis for ground testing, modeling, and simulation of developmental payload performance applicable to a range of possible FE-1 concepts, being studied as a way to inform potential future strike capability determinations.

2.2 Regulatory Setting

The Compact of Free Association between the RMI and the US (48 US Code [USC], Section [§] 1921) requires all US Government activities at USAG-KA (formerly known as US Army Kwajalein Atoll [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 2016). 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 2016).

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 require 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, which does not participate in the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

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 2016), 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.

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, and descriptions of the regulatory setting, consultation history, environmental stressors, and mitigation measures that are relevant to the Proposed Action. This BA addresses FE-1 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 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 USAG-KA, monitoring throughout the flight, and post-impact terminal end operations in the vicinity of USAG-KA.

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 1 (FE-1) Representative Flight Path (curved yellow line) and Sensors.

Spent Rocket Motor Drop Zones. The US Navy SSP FE-1 program launch vehicle consists of a 3stage 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



Figure 3-2. Representative Drop Zones (yellow circles) for spent motors and nose fairing assembly.

payload fairing would occur at different points in the open ocean between 130 and 2,778 kilometers (km; 70 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 KTF towards Kwajalein Atoll.

Terminal End. The terminal end of the payload flight would be in the vicinity of USAG-KA 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 consists of pre-flight preparations in the BOA and at USAG-KA, the FE-1 flight test across the BOA, payload impact, and post-flight impact data collection, debris recovery, and cleanup operations at USAG-KA. The Proposed Action would occur in within a year after signing of the Finding of No Significant Impact (FONSI), if approved. The STARS launch vehicle carrying the developmental payload would be launched from the Kauai Test Facility (KTF) at PMRF in Hawai'i (Figure 3-1) and the flight would terminate near USAG-KA 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-1 program 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) stage motor is 1.32 m (52 in) long with a diameter of 1.37 m (54 in). The amount of propellant in the



Figure 3-3. Notional Impact Area at Illeginni Islet, Kwajalein Atoll.



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



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

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 [lbs]) and the vehicle generates approximately 34,019 kg (75,000 lbs) of thrust (USASMDC/ARSTRAT 2011).

Table 5-1. Launch venicle 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 transponder		
Power	Up to nine lithium ion polymer and silver zinc batteries, each weighing between 3 and 40 pounds		
Propulsion/Propellant	Solid Rocket propellant		
Other	Small Class C (1.4) electro-explosive devices , ~3 lbs of pressurized nitrogen gas		

Table 3.1 Launch Vehicle Characteristics

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 micro curies [μ Ci]) 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 most recently analyzed in 2008 in the HRC EIS/OEIS (US Navy 2008). 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 lbs) of tungsten will be contained in the payload. A nose fairing covers the payload until separation from the third stage motor. This nose fairing is approximately 3.12 m (100 in) long composed 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.

Structure	Aluminum, steel, titanium, magnesium and other alloys, copper, fiber glass, chromate coated hardware, tungsten, plastic, teflon, quartz, RTV silicone
Communications	Two less-than-20-watt radio frequency transmitters
Power	Up to three lithium ion polymer batteries, each weighing between 3 and 50 pounds
Propulsion/Propellant	None
Other	Class C (1.4) electro-explosive devices for safety and payload subsystems operations

Table 3-2	. Payload	System	Characteristics
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3.2.2 Pre-Flight Preparations in the BOA and at USAG-KA.

Sensor Coverage in the BOA. The flight path would essentially be the same as that analyzed in the Final Environmental Impact Statement for the Strategic Target System (USASDC 1992) and the HRC EIS/OEIS (US Navy 2008). A series of sensors would overlap coverage of the flight from launch at KTF until impact at USAG-KA, as shown in Figure 3-1. The sensors would include:

- Ground-based optics and radars at PMRF;
- Sea-based sensors on the Mobile Aerial Target Support System (MATSS) out of PMRF, the Kwajalein Mobile Range Safety System (KMRSS) on board the US Motor Vessel (USMV) Worthy, and the Raytheon Portable Instrumented Range Augmentation Telemetry Equipment System (PIRATES); and
- The C-26 Safety Relay aircraft, based at PMRF, for "off-axis" range safety and support.
- Additional airborne and waterborne sensors on military or commercial aircraft are not planned as part of the FE-1 flight test but might be scheduled by other agencies to collect data on FE-1.

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

Sensor Coverage at USAG-KA. Radars would be placed on Illeginni Islet to gather information on the payload. Up to four radar units which are less than 0.4 m³ (14 ft³) would be placed within the impact area and may be destroyed by payload impact. These radars are powered by automobile batteries or on-shore generator power.

In addition to land-based radars and sensor vessel support, up to 16 self-stationing rafts with onboard optical and/or acoustical sensors (Figure 3-6) may be placed in nearshore ocean waters near Illeginni Islet. Before the flight test, one or two of the range landing craft utility (LCU) vessels would be used to deploy the rafts. The rafts would be equipped with battery-powered electric motors for propulsion to maintain position in the water. Sensors on the rafts would collect data during the experiment's descent until impact.



Figure 3-6. Notional Locations of Precision Scoring Augmentation Rafts.

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-1 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 3-3). 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. Range Safety issues would also be part of selecting the impact scenario.

If the launch vehicle were to deviate from its specified course or should other problems occur during the test flight that would jeopardize public safety, the onboard flight termination system (FTS) would be activated. The FTS would initiate a safe mode for the vehicle, causing it to terminate flight and fall towards the ocean. No-impact boundaries are preprogrammed in the flight safety software and are computer-monitored to avoid any early termination debris falling on inhabited areas. The FTS is also programmed to detect premature separation of the booster stages and to terminate thrust by venting the motor chamber with an explosive charge, resulting in vehicle components descending into the ocean.

During the planned FE-1 flight over the BOA, 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. Jettison of the fairing and payload separation from the fairing would occur inside the atmosphere. Splashdown of all three spent motor stages and the fairing would occur at different points in the open ocean between 130 and 2,778 km (70 and 1,500 nm) from the launch pad. Figure 3-2 depicts the drop zones for the rocket motors. The nose fairing is expected to splashdown in motor drop zone 2.

Following separation from the launch vehicle, the payload would use autonomous flight control to fly at high-speeds in the upper atmosphere towards RTS. If the payload's onboard computers determine that there is insufficient energy to reach the target area, the payload would be directed to descend in a controlled termination of the flight into the BOA.

Upon reaching the terminal end of the flight, the payload would impact on the non-forested northwestern end of Illeginni Islet (Figures 3-3 and 3-4). A crater would form as a result of this impact and leave debris containing less than 454 kg (1,000 lbs) of tungsten¹. 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.

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. 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 Island for proper disposal in the US. Following cleanup and repairs to the Illeginni site, soil samples would be collected at various locations around the impact area and tested for pertinent contaminants. Recovery and cleanup operations on Illeginni Islet could possibly cause some short-term disturbance to migratory bird habitat, potential sea turtle nesting habitat, and nearshore coral reef habitat.

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, within 500 to 1,000 ft of the shoreline, are 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, a dive team from USAG-KA or RTS would be brought in to conduct underwater searches. Also under consideration for underwater debris recovery is the use of ROVs. If warranted due to other factors, such as significant currents, mass of the debris to be recovered, etc., the recovery team would consider the use of a remotely operated vehicle (ROV) instead of divers.

¹ The payload debris would include tungsten for ballast, etc., in accordance with Table 2-2; 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 1,000 pounds of tungsten alloy is used for the environmental effects analysis.

If an inadvertent impact occurs on the reef, reef flat, or in shallow waters less than 30.5 m (100 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.

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 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, 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) below.

3.3.1 Exposure to Elevated Sound Levels

The Proposed Action has the potential to result in elevated sound pressure levels 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 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 sound pressure levels for the FE-1 flight test have been estimated and are detailed in Appendix A and section 5.1.1 below.

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

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 sound pressure levels of 140 decibels (dB) at 18 m (59 ft; Navy Personal Communication 2016). These levels are used as a bounding case for the current 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 are expected to be less than those of MMIII reentry vehicles (RVs). Therefore, MMII estimates of cratering and shock waves (USAFGSC and USASMDC/ARSTRAT 2015) are used as a maximum bounding case for the Proposed Action.

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-1 flight test monitoring and data collection, sea based sensors will be deployed along the flight path on vessels in the BOA. These three vessels (Figure 3-1) will travel from PMRF or USAK-GA to locations along the flight path.

Pre-flight activities at or near USAG-KA 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. Approximately 4 vessel round trips to Illeginni 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. Approximately 4 vessel round trips to Illeginni 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 near the shoreline, debris would be recovered. Smaller boats will transport divers, and ROVs if needed, to and from Illeginni to locate and recover this debris in waters up to approximately 30.5 m (100 ft) deep on the ocean side of Illeginni and within 152 to 305 m (500 to 1,000 ft) of the islet's shoreline on the lagoon side.

3.3.4 Exposure to Hazardous Chemicals

The Proposed Action has the potential to introduce hazardous chemicals into the Action Area. Splashdown 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 453 kg (1,000 lbs) of tungsten. While attempts will be made to recover all tungsten and other visible debris, some may remain in the impact area at Illeginni. 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 US. 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.

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-1 activities will take place in the BOA except of sensor carrying vessels returning to their place of origin.

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, approximately 8 vessel round-trips are likely. Helicopters will also be used to transport equipment and personnel to Illeginni with 2 to 4 daily trips planned. The Action is expected to involve as many as 2 dozen personnel on Illeginni during the 10 weeks period.

At Illeginni, 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 30.5 m (100 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, within 152 to 305 m (500 to 1,000 ft) of the shoreline, 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 (up to approximately 49 m or 160 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.

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 15 to 30.5 m (50 to 100 ft). An underwater operation similar to a lagoon recovery would be used if debris were located in this area. If the payload should impact in the ocean beyond shallow waters, it would not be recovered.

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 based on expected animal locations, densities, and or lighting and turbidity conditions.
- If personnel observe sea turtles or marine mammals in potential impact zones, sightings would be reported to appropriate test and USAG-KA personnel for consideration in launch planning.
- 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 USAG-KA 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-1 launch, Illeginni Islet would be surveyed by pre-test personnel for sea turtles, sea turtle nesting activity, and sea turtle nests on a bi-weekly basis. If possible, personnel will inspect the area within two 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 off Illeginni Islet, sensor rafts would not be located in waters less than 3 m (10 ft) deep.
- 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.
- 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.
- 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.

- 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.
- As soon as practical following payload impact at Illeginni Islet, qualified biologists would be allowed to assist in recovering and rehabilitating any injured sea turtles found.
- 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.
- To minimize impacts during post-flight operations, USFWS and NMFS would be allowed to provide guidance and/or assistance during recovery and cleanup at Illeginni Islet. In all cases, recovery and cleanup operations would be conducted in a manner to minimize further harm to biological resources.

4.0 LISTED SPECIES & 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 and (b) Illeginni Islet impact zone including adjacent shallow waters. 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, 19 coral, and 2 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					
Cetaceans					
Balaenoptera acutorostrata	Minke whale	LC	MMPA		
B. borealis	Sei whale	EN	ESA-Endangered, MMPA-Depleted		
B. edeni	Bryde's whale		MMPA		
B. musculus	Blue whale	EN	ESA-Endangered, MMPA-Depleted		
B. physalus	Fin whale	EN	ESA-Endangered, MMPA-Depleted		
Delphinus delphis	Short-beaked common dolphin	LC	MMPA		
Feresa attenuata	Pygmy killer whale		MMPA		
Globicephala macrorhynchus	Short-finned pilot whale		MMPA		
Grampus griseus	Risso's dolphin	LC	MMPA		
Indopacetus pacificus	Longman's beaked whale		MMPA		
Kogia breviceps	Pygmy sperm whale		MMPA		
K. sima	Dwarf sperm whale		MMPA		
Lagenodelphis hosei	Fraser's dolphin	LC	MMPA		
Megaptera novaeangliae	Humpback whale	LC	ESA-Endangered ¹ , MMPA-Depleted		
Mesoplodon densirostris	Blainville's beaked whale		MMPA		
Orcinus orca	Killer whale		MMPA		
Peponocephala electra	Melon-headed whale	LC	MMPA		
Physeter macrocephalus	Sperm whale	VU	ESA-Endangered, MMPA-Depleted		
Pseudorca crassidens	False killer whale		ESA- Endangered (Insular Hawaiian DPS), MMPA-Depleted		
Stenella attenuata	Pantropical spotted dolphin	LC	MMPA-Depleted		
S. coeruleoalba	Striped dolphin	LC	MMPA		
S. longirostris	Spinner dolphin		MMPA-Depleted		
Steno bredanensis	Rough-toothed dolphin	LC	MMPA		
Tursiops truncatus	Bottlenose dolphin	LC	MMPA-Depleted		
Ziphius cavirostris	Cuvier's beaked whale	LC	MMPA		
Phocids					
Neomonachus schauinslandi	Hawaiian monk seal	EN	ESA-Endangered, MMPA-Depleted		
Birds					
Puffinus auricularis newelli	`A`o (Newell's shearwater)	EN	ESA-Threatened		

Scientific Name	Common Name	IUCN Status†	Listing Status ‡		
Sea Turtles					
Caretta caretta	Loggerhead turtle	VU	ESA-Endangered ²		
Chelonia mydas	Green turtle	EN	ESA-Threatened, Endangered ³		
Dermochelys coriacea	Leatherback turtle	VU	ESA-Endangered		
Eretmochelys imbricata	Hawksbill turtle	CR	ESA-Endangered		
Lepidochelys olivacea	Olive ridley turtle	VU	ESA-Threatened, Endangered ⁴		
Fish					
Alopias superciliosus	Bigeye thresher shark	VU	UES		
Carcharhinus longimanus	Oceanic whitetip shark	VU	ESA-Proposed Threatened		
Cheilinus undulatus	Humphead wrasse	EN	UES		
Manta alfredi	Reef manta ray	VU	UES		
M. birostris	Oceanic giant manta ray	VU	ESA-Proposed Threatened		
Sphyrna lewini	Scalloped hammerhead	EN	ESA-Threatened (Indo-West Pacific		
			Distinct Population Segment)		
Thunnus orientalis	Pacific bluefin tuna	VU	ESA- Candidate		
Corals					
Acanthastrea brevis		VU	UES		
Acropora aculeus		VU	UES		
A. aspera		VU	UES		
A. dendrum		VU	UES		
A. listeri		VU	UES		
A. microclados		VU	UES		
A. polystoma		VU	UES		
A. speciosa		VU	ESA- Threatened		
A. tenella		VU	ESA- Threatened		
A. vaughani		VU	UES		
Alveopora verilliana		VU	UES		
Cyphastrea agassizi		VU	UES		
Heliopora coerulea		VU	UES		
Leptoseris incrustans		VU	UES		
Montipora caliculata		VU	UES		
Pavona cactus		VU	UES		
P. venosa		VU	UES		
Turbinaria reniformis		VU	UES		
T. stellulata		VU	UES		

Mollusks

Pinctada margaritifera	Black-lipped pearl oyster	NE	UES	
Trochus niloticus ⁵	Top shell snail	NE	UES	

Sources: USASMDC 2009; Sakashita and Wolf 2009; IUCN 2015; NMFS 2015d

†IUCN: International Union for Conservation of Nature, CR: Critically Endangered, EN: Endangered, LC: Least Concern, NE: Not Evaluated, VU: Vulnerable

‡ESA: US Endangered Species Act, MMPA: Marine Mammal Protection Act, UES: UES protection (USASMDC/ARSTRAT 2016 Section 3-4.5.1)

¹The distinct population segments of humpback whales likely in the Action Area are not listed under the endangered species act; however there is some uncertainty about which distinct population segment whales in the Action Area belong to (see section 4.1.14 below). ²North Pacific Ocean Distinct Population Segment.

³As a species, the green turtle is currently listed as threatened and the Mexican Pacific Coast nesting population is listed as endangered. Distinct Population Segments (DPSs) have been identified and populations in the Action Area belong to two DPSs. The central north Pacific DPS is proposed threatened and the central western Pacific DPS is proposed endangered (Seminoff et al. 2015).

⁴As 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).

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

4.1 Marine Mammals

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 occur in the central and western Pacific (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 further 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. Three 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.

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, 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. Regarding noise exposure, 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 sound pressure levels in air are referenced to (re) 20 micro-Pascals (μ Pa), underwater sound levels are normalized to 1 μ Pa 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 to 1 μ Pa). A passing supertanker can generate up to 190 dB (re to 1 μ Pa) of low frequency sound.

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

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

Sources: NMFS 2015d; Miller 2007

E: Endangered, D: Depleted, P-E: Proposed Endangered, MMPA: Marine Mammal Protection Act, All species in this table are protected under the UES where they occur in waters of the Marshall Islands.

L-Likely; P – Potential; U – Unlikely

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 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, eleven 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 is 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.

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. They are lunge feeders, often plunging through patches of shoaling fish or krill (Hoelzel et al. 1989). 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). There are no tests or modeling estimates of specific minke whale hearing ranges. Minke whales, like other baleen whales, are known to use low-frequency sounds to communicate with one another (NMFS 2015d).

Distribution. The distribution of minke whales is considered cosmopolitan. These whales feed mostly in cool temperate to boreal waters at higher latitudes but are also found in tropical and subtropical areas (NMFS 2015d). Minke whales generally migrate annually between low-latitude breeding grounds in the winter and high-latitude feeding grounds in the summer (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).

Threats. The Minke 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 minke whales.

Populations in the Action Area.

<u>Broad Ocean Area</u>: 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 (PISFC 2010a; PISFC 2010b). One minke whale was sighted on a January/February 2010 cruise (PISFC 2010a) and there were 23 acoustic detections of the species on the April/May 2010 cruise (PISFC 2010b).

<u>Vicinity of Illeginni Islet</u>: 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. 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). While no data on hearing ability for this species are available, Ketten (1997) hypothesized that mysticetes have acute infrasonic hearing. In terms of functional hearing capability, sei whales belong to low-frequency cetaceans that have functional hearing ranging from 7 Hz to 22 kHz (Southall et al. 2007). There are no tests or modeling estimates of specific sei whale hearing ranges.

Distribution. Sei whales have a worldwide distribution and are found primarily in cold temperate to subpolar latitudes. During the winter, sei whales are found from 20° N to 23° N and during the summer from 35° N to 50° N (Horwood 2009; Smultea et al. 2010). 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; Gregr and Trites 2001) and are usually observed in deeper waters of oceanic areas far from the coastline (NMFS 2015d). Sei whales spend the summer feeding in high subpolar latitudes and return to lower latitudes to calve in winter. They are considered absent or at very low densities in most equatorial areas and are therefore unlikely to be present in high numbers in the Action Area.

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. 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. Secondary occurrence is expected in deep waters on the north side of the islands only. In 2007 two sei whale sightings occurred north of Oahu during a short survey in November, including one sighting of three subadults. These latter sightings suggest that the area north of the main Hawaiian Islands may be part of a reproductive area for North Pacific sei whales (Smultea et al. 2010). Sightings have occurred primarily from July to September. A 2010 shipboard line-transect surveys of the Hawaiian Islands stock resulted in a summer/fall abundance estimate of 178 (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 (PISFC 2010a; PISFC 2010b). Three sei whales were sighted on a January/February 2010 cruise (PISFC 2010a) and there was one observation of a sei or Bryde's whale in both January/February and April/May 2010 cruises (PISFC 2010b).

<u>Vicinity of Illeginni Islet</u>: 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. Bryde's whales are a type of baleen whale, which primarily feeds on schooling fish and are lunge feeders. The Bryde's whale does not have a well-defined breeding season in most areas, with some breeding occurring throughout the year. While no data on hearing ability for this species are available, Ketten (1997) hypothesized that mysticetes have acute hearing at frequencies below the normal limit of human hearing. In terms of functional hearing capability, 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 40° south to 40° north (NMFS 2015d). 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 (NMFS 2015d). Some populations of Bryde's whales migrate seasonally while other populations are residents (NMFS 2015d). 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). Bryde's whales might dive for as long as 20 minutes and to depths of 300 m (985 ft; Kato and Perrin 2009). They are sometimes seen very close to shore and even inside enclosed bays (Baker and Madon 2007; Best et al. 1984).

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. There are no known threats in the Action Area that are specific to only Bryde's whales.

Populations in the Action Area.

<u>Broad Ocean Area</u>: 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). Bryde's whales may have been detected on surveys conducted between the Hawaiian Islands and Guam via Wake Island (PISFC 2010a; PISFC 2010b). One sei or Bryde's whale was sighted on a January/February 2010 cruise (PISFC 2010a) and one sei or Bryde's whale was sighted on the April/May 2010 cruise (PISFC 2010b).

<u>Vicinity of Illeginni Islet</u>: Bryde's whales have been identified in many Pacific island chains, including the RMI. 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. This species is a type of baleen whale, which preys almost exclusively on various types of zooplankton, especially krill. They lunge feed and consume approximately 5,500 kg (6 tons) of krill per day (Pitman et al. 2007). They sometimes feed at depths greater than 100 m (330 ft),

where their prey maintains dense groupings (Acevedo-Gutiérrez et al. 2002). While no data on hearing ability for this species are available, Ketten (1997) hypothesized that baleen whales have acute infrasonic hearing. Based on vocalizations and anatomy, blue whales are assumed to predominantly hear low-frequency sounds below 400 Hz (Croll et al. 2001; Oleson et al. 2007). In terms of functional hearing capability, blue whales belong to the low-frequency group, with hearing ranging from 7 Hz to 22 kHz (Southall et al. 2007).

Distribution. The blue whale inhabits all oceans and while they are found in coastal waters, they are also known to occur more offshore than many other whales (NMFS 2015d). Blue whales in the 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 (NMFS 2015d). Blue whales travel alone or with one to two individuals; little is otherwise known about the travelling behavior of the species. Calving occurs 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.

Populations in the Action Area.

<u>Broad Ocean Area</u>: Blue whales are found in the Hawai`i portion of the BOA, but this species is known to occur seasonally in this region, and sighting frequency is low. Whales feeding along the Aleutian Islands of Alaska likely migrate to offshore waters north and west of Hawai`i in winter (Stafford et al. 2004; Watkins et al. 2000). Little is known about the current population size of blue whales in the Pacific. 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).

<u>Vicinity of Illeginni Islet</u>: 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). 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 another type of baleen whale, is the second largest species of whale (Jefferson et al. 2008). 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). 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). Although no studies have directly measured the sound sensitivity of fin whales, experts assume that fin whales are able to receive sound signals in roughly the same frequencies as the signals they produce. This suggests fin whales, like other baleen whales, are

more likely to have their best hearing capacities at low frequencies, including frequencies lower than those of normal human hearing, rather than at mid- to high frequencies (Ketten 1997).

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 (NMFS 2015d, 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). In 2009 there were an estimated 140,000 fin whales globally, and they were relatively abundant in the Pacific (Mizroch et al. 2009). 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). These whales are known to migrate seasonally; however, their migration patterns are not well known (NMFS 2015d).

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. There are no known threats in the Action Area that are specific to only fin whales.

Populations in the Action Area.

<u>Broad Ocean Area</u>: The distribution of fin whales in the Pacific during the summer includes the Hawai`i portion of the BOA to 32° N (Barlow 1995; Forney et al. 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 (km²; per 39 square miles [mi²]) 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).

<u>Vicinity of Illeginni Islet</u>: 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, 3 m (9 ft) long dolphins are usually found in large social groups and are often active at the surface. Short-beaked common dolphins are usually found in large social groups of hundreds of individuals and are capable of diving to at least 200 m (650 ft) to feed on fish (NMFS 2015d). Common dolphins in some populations appear to prefer to travel along bottom topographic features, such as escarpments and seamounts (Bearzi 2003). 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 with large seasonal changes in surface temperature and thermocline depth (the point between warmer surface water and colder water; Au and Perryman 1985). 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 areas and seasons (Jefferson et al. 2008) where waters are 200-2,000 m (650-6,500 ft) deep (NMFS)
2015d). Canadas 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 have been documented near California. In the north Pacific, the short-beaked common dolphins is found primarily off the coast of North America, north of the Hawaiian islands, and at northern latitudes west to Japan and parts of the Indian Ocean (NMFS 2015d, 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.

<u>Broad Ocean Area</u>: 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).

<u>Vicinity of Illeginni Islet</u>: 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 potential occurrence near Illeginni.

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. 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 (NMFS 2015d). Because it is a tropical species, calving probably occurs throughout the year. 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. This species is generally an open ocean deep-water species of the tropics and subtropics (Davis et al. 2000; Wursig et al. 2000). The open ocean range of the pygmy killer whale generally extends along the equatorial regions, generally south of 40° N and continuous across the Pacific (Donahue and Perryman 2008). 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.

<u>Broad Ocean Area</u>: This species may occur in the BOA of the Action Area; however, it is not likely to occur here as the only documented occurrences in the western Pacific Ocean are in French Polynesia. The pygmy killer whale is 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.

<u>Vicinity of Illeginni Islet</u>: 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 3.7 to 5.5 m (12 to18 ft) long type of toothed whale. These whales occur in groups of 25 to 50 animals and feed primarily on squid, octopus, and fish in waters 305 m (1000 ft) deep or more (NMFS 2015d). The region of best hearing for pilot whales is between 11.2 and 50 kHz (relatively poor high frequency hearing, compared with other odontocete species; Pacini et al. 2010). A complete audiogram had the common U-shape found in mammals and was overall similar to other odontocete audiograms (Kastelein et al. 2002), with a steep slope in the high-frequency region and a more leveled slope in the lower frequencies. The region of best hearing was between 11.2 and 50 kHz, with thresholds below 70 dB re 1 μ Pa. The best hearing was found at 40 kHz, with a 53.1 dB re 1 μ Pa threshold. The slope of the thresholds became very steep above 50 kHz, and the poorest sensitivity was measured at both ends of the frequency spectrum, with 77 dB re 1 μ Pa at 4 kHz and 124 dB re 1 μ Pa at 100 kHz.

Distribution. The short-finned pilot whale is widely distributed throughout most tropical and warm temperate waters of the world. This species occurs mainly in deep offshore areas, so it occupies waters over the continental shelf break, in slope waters, and in areas of high topographic relief. Short-finned pilot whales are not considered a migratory species, although seasonal shifts in abundance have been noted in some portions of its range. 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.

Populations in the Action Area.

<u>Broad Ocean Area</u>: This species is commonly observed around the Hawaiian Islands (Carretta et al. 2014) and likely occurs in surrounding deeper offshore areas. 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).

<u>Vicinity of Illeginni Islet</u>: 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. Cephalopods and crustaceans are the primary prey for Risso's dolphins (Clarke 1996), which feed mainly at night (Jefferson et al. 2008). Individuals may remain submerged on dives as long as 30 minutes and to dive as deep as 600 m (1,970 ft; DiGiovanni et al. 2005). These dolphins are typically

found in groups which average between 10 and 30 dolphins (NMFS 2015d). Nachtigall et al. (1995) measured hearing in an adult Risso's dolphin in a natural setting, with natural background noise, using behavioral methods. The adult hearing ranged from 1.6 to 100 kHz and was most sensitive between 8 and 64 kHz. The auditory brainstem response technique was used to measure hearing in a stranded infant Risso's dolphin. Hearing ranged from 4 to 150 kHz, with best sensitivity at 90 kHz. The full range of functional hearing for this species 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. Risso's dolphins occur in temperate, subtropical, and tropical waters throughout the world (NMFS 2015d). These dolphins are found offshore, along the continental slope, and over the outer continental shelf (Baumgartner 1997; Canadas et al. 2002) in waters that are generally greater than 1,000 m (3,300 ft; NMFS 2015d). In the North Pacific, off California, calving peaks in either summer/fall or fall/winter. Risso's dolphins do not migrate, although schools may range over very large distances with shifting prey abundance, and seasonal shifts in centers of abundance are known for some regions. 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. There are no known threats in the Action Area that are specific to only Risso's dolphins.

Populations in the Action Area.

<u>Broad Ocean Area</u>: 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).

<u>Vicinity of Illeginni Islet</u>: 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. It is a rare beaked whale species and, until recently, was considered to be the world's rarest cetacean. Little information is available on life history for this species of toothed whale. Based on recent tagging data, Baird et al. (2005) suggested that feeding for this species might occur at mid-water rather than only at or near the bottom. These whales are usually found in tight groups of 10 to 20 but may be found in larger groups (NMFS 2015d). From anatomical examination of their ears, beaked whales are presumed to be predominantly adapted to best hear ultrasonic frequencies (MacLeod 1999). Beaked whales may be more sensitive than other cetaceans to low-frequency sounds (MacLeod 1999). The full range of functional hearing for beaked whales is estimated to occur between approximately 150 Hz and 160 kHz (Southall et al. 2007).

Distribution. Longman's beaked whales are considered to be widely distributed across the tropical Pacific and Indian Oceans (Jefferson et al. 2008). Worldwide, Longman's beaked whales normally inhabit continental slope and deep oceanic waters (greater than 1,000 m [3,300 ft]), and are only

occasionally reported in waters over the continental shelf (Waring et al. 2001). They generally are found in warm tropical waters, with most sightings occurring in waters with sea surface temperatures warmer than 79° F (26° C; 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. There are no known threats in the Action Area that are specific to only Longman's beaked whales.

Populations in the Action Area.

<u>Broad Ocean Area</u>: 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).

<u>Vicinity of Illeginni Islet</u>: 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 are considered to be a deep-diving species, based on stomach contents, oxygen levels in the blood, and long dive durations (Bloodworth and Odell 2008). Pygmy sperm whales are a type of toothed whale, which feeds on cephalopods and, less often, on deep-sea fishes and shrimps (Beatson 2007). An auditory brainstem response study completed on a stranded pygmy sperm whale indicated best 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 (NMFS 2015d). These whales are thought to be more oceanic than other *Kogia* species, being most common in waters seaward of the continental shelf edge and slope (NMFS 2015d). The pygmy sperm whale frequents more temperate habitats than the other *Kogia* species and is considered a more anti-tropical species (NMFS 2015d). Little is known about possible migrations of this species. No specific information regarding routes, seasons, or resighting rates in specific areas is available.

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. 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.

<u>Vicinity of Illeginni Islet</u>: Pygmy sperm whales have been documented in French Polynesia and in Guam, 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). They are considered to be a deep-diving species, based on stomach contents, blood oxygen levels, and long dive durations (Bloodworth and Odell 2008). 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 (NMFS 2015c). 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 (MacLeod et al. 2004). Dwarf sperm whales have been observed in outer continental shelf, slope, and more oceanic waters. No specific information regarding routes, seasons, or resighting rates of dwarf sperm whales in the Pacific is 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. There are no known threats in the Action Area that are specific to only dwarf sperm whales.

Populations in the Action Area.

<u>Broad Ocean Area</u>: 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 2010 shipboard surveys of the Hawaiian Islands EEZ.

<u>Vicinity of Illeginni Islet</u>: This species is not known to occur in the vicinity of Illeginni Islet. Dwarf sperm whales have been documented in French Polynesia and in Guam, but 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. Fraser's dolphins have been observed in groups of 10 to 100 individuals (NMFS 2015d) and feed on mid-water fishes, squids, and shrimps (Jefferson and Leatherwood 1994; Perrin et al. 1994). Available data do not show strong evidence of calving seasonality, but slight peaks may occur in spring, summer, or fall. 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 with a cosmopolitan distribution (NMFS 2015d). 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 (NMFS 2015d). In the offshore eastern tropical Pacific, this species is distributed mainly in upwelling-modified waters (Au and Perryman 1985; Reilly 1990). This does not appear to be a migratory species, and little is

known about its potential migrations. No specific information regarding routes, seasons, or resighting rates in specific areas is available.

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. There are no known threats in the Action Area that are specific to only Fraser's dolphins.

Populations in the Action Area.

<u>Broad Ocean Area</u>: 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 (Carretta et al. 2011); however, there is no known more recent occurrence information for this area.

<u>Vicinity of Illeginni Islet</u>: 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 (Federal Register 81: 62259-62320 [October 11, 2016]). The Mexico DPS is listed as threatened under the ESA, 4 DPSs are listed as endangered under the ESA, and the remaining 9 DPSs are not listed under the ESA (NMFS 2016). In the western and central Pacific, there are 3 DPSs; the Hawai'i DPS (not listed), the Oceania DPS (not listed), and the Western North Pacific DPS (endangered; NMFS 2016). The populations 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 (NMFS 2015d). All populations of humpback whale are considered depleted under the MMPA. These whales have Humpbacks are baleen whales, which typically feed on shallow banks or ledges with high seafloor relief (Hamazaki 2002). 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). Humpback whales feed on a variety of invertebrates and small schooling fishes, both at the surface and in deeper waters. Humpbacks spend most of their time in the upper 120 m (395 ft) of the water column on the feeding grounds (Dietz et al. 2002).

In terms of functional hearing capability, humpback whales are considered low-frequency cetaceans, with hearing ranging 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. The ability of humpbacks to hear frequencies around 3 kHz may have been demonstrated in a playback study. Maybaum (1989) reported that humpback whales showed a mild response to a handheld sonar detection and location device with frequency of 3.3 kHz at 219 dB re 1µPa-m or frequency sweep of 3.1 to 3.6 kHz.

Distribution. The humpback whale is found in throughout the world in all ocean basins (Carretta et al. 2015). Some stocks are apparently still depleted from whaling, but most are showing strong evidence of recovery (Calambokidis and Barlow 2004). They typically are 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. 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).

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. There are no known threats in the Action Area that are specific to only humpback whales.

Populations in the Action Area.

<u>Broad Ocean Area</u>: 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 feeds/summers 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). During spring and summer, secondary occurrence is expected offshore out to 93 km (50 nm). 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).

<u>Vicinity of Illeginni Islet</u>: 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. As for other beaked whale species, Blainville's beaked whales appear to prefer deep waters for feeding and are known to be deep divers. From anatomical examination of their ears, beaked whales are presumed to be predominantly adapted to best hear ultrasonic frequencies (MacLeod 1999). Beaked whales may be more sensitive than other cetaceans to low-frequency sounds (MacLeod 1999). The full range of functional hearing for beaked whales is estimated to occur between approximately 150 Hz and 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 (Jefferson et al. 2008, MacLeod et al. 2006). They are found

mostly offshore in deeper waters along the California coast, Hawai`i, Fiji, Japan, and Taiwan, as well as throughout the eastern tropical Pacific (Leslie et al. 2005; MacLeod and Mitchell 2006). These whales have been found to prefer water depths of 200 to 1,000 m (656 to 3,280 ft; IUCN 2015). It is unknown whether this species makes specific migrations, and none have so far been documented.

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.

<u>Broad Ocean Area</u>: 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 protected 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 (NMFS 2015d). Behavioral and auditory evoked potential audiograms of two captive killer whales indicate that they can hear tones ranging from 1 to 120 kHz (best hearing ranging from 18 to 42 kHz), with most sensitivity at 20 kHz, with a detection threshold of 36 dB re 1 μ Pa (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. 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 recognizable geographic forms are variously known as residents, transients, and offshore ecotypes (Hoelzel et al. 2007). 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. Although killer whales are also found in tropical waters and the open ocean, they prefer

colder waters and are found in greatest abundance within 800 km (432 nm) of major continents (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, there are often seasonal shifts in density, both onshore/offshore and north/south.

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. There are no known threats in the Action Area that are specific to only killer whales.

Populations in the Action Area.

<u>Broad Ocean Area</u>: 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). These sightings are extremely infrequent and typically occur during winter, suggesting no resident population in Hawai`i (Mobley et al. 2001). 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).

<u>Vicinity of Illeginni Islet</u>: 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. 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). 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. They have occasionally been reported at higher latitudes, but these movements are considered to be beyond their normal range, because the records indicate these movements occurred during incursions of warm water currents (Perryman et al. 1994). Melon-headed whales are most often found in offshore deep waters but sometimes move close to shore over the continental shelf. Brownell et al. (2009) found that melon-headed whales near oceanic islands rest near shore during the day and feed in deeper waters at night. This species is not known to migrate.

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, five 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.

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. There are no known threats in the Action Area that are specific to only melon-headed whales.

Populations in the Action Area.

<u>Broad Ocean Area</u>: 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 2500 m (8,202 ft) deep water off Kohala peninsula and the west coast of Hawai'i Island (Carretta et al. 2014). The main Hawaiian Islands stock is occurs throughout the Hawaiian Islands EEZ; however, data on abundance and distribution and largely lacking (Carretta et al. 2014). 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 3 individuals were sighted on the April/May 2010 cruise along with additional acoustic detections (PISFC 2010b).

<u>Vicinity of Illeginni Islet</u>: 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.

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 toothed whales, which socialize for predator defense and foraging, feeding on squid and other cephalopods and bottom-dwelling fish and invertebrates (Davis et al. 2007; Rice 1989). These large whales spend most of their time in deep waters where their prey, large squid, sharks, skates, and fishes, are found (NMFS 2015d).

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). Other hearing information consists of indirect data. For example, the anatomy of the sperm whale's inner and middle ear indicates an ability to best hear high frequency to ultrasonic hearing (Ketten 1992). The sperm whale may also possess better low-frequency hearing than other toothed whales, although not as low as many baleen whales (Ketten 1992). 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 μ Pa2 between 250 Hz and 1.0 kHz) interrupted sperm whale acoustic activity and resulted in the animals converging on the vessel. The full range of functional hearing for the sperm whale 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. 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), tending to inhabit areas with water 600 m (1968 ft) or more deep (NMFS 2015d). These whales are uncommon in waters less than 300 m (984 ft) deep (NMFS 2015d); however, 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). Female sperm whales are typically found far from land. Typically, sperm whale concentrations correlate with areas of high productivity, which are generally near drop-offs and areas with strong currents and steep topography (Gannier and Praca 2007). Sperm whales are somewhat migratory depending on their location, gender, and prey abundance (NMFS 2015d). 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). Surveys of the eastern tropical Pacific reveal that although sperm whales are widely distributed in the tropics, their relative abundance appears to taper off markedly westward towards the middle of the tropical Pacific (Wade and Gerrodette 1993).

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. There are no known threats in the Action Area that are specific to only sperm whales.

Populations in the Action Area.

<u>Broad Ocean Area</u>: The sperm whale's range occurs throughout the BOA. This species is typically found in the temperate and tropical waters of the Pacific (Rice 1989). Sperm whales are found year-round in Hawaiian waters and are one of the more abundant large whales found in that region (Mobley et al. 2000). 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 4 were sighted on an April/May 2010 cruise along with additional acoustic detections (PISFC 2010b).

<u>Vicinity of Illeginni Islet</u>: There have been documented occurrences of sperm whales in the Illeginni Islet area of Kwajalein Atoll. In 2000, a pod of approximately 12 endangered sperm whales was seen a few miles southeast of Illeginni. On August 5, 2006, there were two whales 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° 00.27N; 167° 01.30W), 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 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, there was one whale 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 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. No pronounced breeding season is known for the false killer whale, although one population has an apparent calving peak in late winter. False killer whales are a type of toothed whale, which feed primarily on deep-sea cephalopods and fish (Odell and McClune 1999). 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 among the group of cetaceans that can hear mid-frequency sounds (Southall et al. 2007).

Distribution. False killer whales prefer tropical to temperate waters that are deeper than 1,000 m (3,300 ft; NMFS 2015d). While the species is not considered rare, few areas of high density are known. 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 140 km (75 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 are not considered a migratory species, although seasonal shifts in density likely occur.

Threats. 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 the National Oceanic and Atmospheric Administration 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 (Federal Register 77: 71259[November 29, 2012]).

Populations in the Action Area.

<u>Broad Ocean Area</u>: This species is known to occur near the Hawaiian Islands and in surrounding deep ocean areas. The Hawai'i pelagic stock was estimated to be 1,552 (CV = 0.66) whales outside 40 km (22 nm) of the main Hawaiian Islands based on 2010 shipboard line-transect surveys (Carretta et al. 2015). This estimate may be biased high as false killer whales have demonstrated some vessel attraction (Carretta et al. 2015). Little is known about false killer whale distributions in the BOA but the species has the potential to occur in the BOA of the Action Area. False killer whales have also 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).

<u>Vicinity of Illeginni Islet</u>: 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; NMFS 2016).

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. Pantropical spotted dolphins are known to breed year-round, but in the eastern tropical Pacific, where this species has been studied most thoroughly, two calving peaks occur (one in spring and one in fall). Pantropical spotted dolphins prey on near-surface fish, squid, and crustaceans and on some mid-water species (Perrin and Hohn 1994). Results from various tracking and food habit studies suggest that pantropical spotted dolphins 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).

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 among the group of cetaceans that can hear mid-frequency sounds (Southall et al. 2007).

Distribution. The pantropical spotted dolphin is distributed in offshore tropical and subtropical waters of the Pacific, Atlantic, and Indian oceans, between about 40° N and 40° S latitudes (Baldwin et al. 1999). The species is much more abundant in the lower latitudes of its range. It is found mostly in deeper offshore waters but does approach the coast in some areas (Perrin 2001). 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 (NMFS 2015d). This species is common in the Hawaiian Islands and surrounding offshore areas. For the MMPA there are 4 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 been 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. There are no known threats in the Action Area that are specific to only pantropical spotted dolphins.

Populations in the Action Area.

<u>Broad Ocean Area</u>: Pantropical spotted dolphins are frequently sighed in pelagic waters. 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).

<u>Vicinity of Illeginni Islet</u>: 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. Striped dolphins often feed in open sea or sea bottom zones along the continental slope, or just beyond it in oceanic waters. Most of their prey species possess light-emitting organs, suggesting that striped dolphins may be feeding at great depths, possibly diving to 200 to700 m (655 to 2,297 ft; Archer and Perrin 1999). Striped dolphins may feed at night in order to take advantage of the deep scattering layer's diurnal vertical movements.

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. Hearing ability became less sensitive below 32 kHz and above 120 kHz. The full audiogram for this animal showed hearing ability from 0.5 to 160 kHz; therefore, the full range of functional hearing for the species is estimated to be 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. Although primarily a warm-water species, the range of the striped dolphin extends higher into temperate regions than those of any other species in the genus Stenella (spotted and spinner/Clymene dolphins). This abundant and widespread species is generally restricted to oceanic regions and are seen close to shore only where deep water approaches the coast. In some areas (e.g., the eastern tropical Pacific), they are mostly associated with convergence zones and regions of upwelling (Au and Perryman 1985; Reilly 1990).

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. There are no known threats in the Action Area that are specific to only striped dolphins.

Populations in the Action Area.

<u>Broad Ocean Area</u>: These dolphins are abundant and widespread in oceanic regions. 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).

<u>Vicinity of Illeginni Islet</u>: While the primary range of the striped dolphin includes the deep ocean waters around USAG-KA 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. 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). They forage primarily at night, when the mid-water community migrates toward the surface and the shore (Benoit-Bird 2004). No empirical data on hearing ability for this species are available, although the full range of hearing may extend down to 150 Hz, as reported for other small odontocetes, and up to at least 65 kHz, based on their echolocation clicks (Richardson 1995; Bazúa-Durán and Au 2002).

Distribution. Spinner dolphins range through oceanic tropical and subtropical zones in both hemispheres (the range is nearly identical to that of the pantropical spotted dolphin). Spinner dolphins occur in both oceanic and coastal habitats. Most sightings of this species have been associated with inshore waters, islands, or banks (Perrin and Gilpatrick 1994). Coastal populations are usually found in island archipelagos, where they are tied to trophic and habitat resources associated with the coast (Norris and Dohl 1980; Poole 1995). Spinner dolphins typically occur from nearshore waters to the 4,000 m (13,123 ft) depth. This takes into account offshore resting habitat and offshore feeding areas. 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). For island-associated stocks, 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).

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. There are no known threats in the Action Area that are specific to only spinner dolphins.

Populations in the Action Area.

<u>Broad Ocean Area</u>: 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).

<u>Vicinity of Illeginni Islet</u>: 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 USAG-KA (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 USAG-KA, it is likely that they are relatively common around Illeginni Islet.

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 squids and fish (NMFS 2015d). These dolphins usually occur in tight-knit groups of 10 to 20 and often associate with other dolphins (NMFS 2015d). 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). 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).

Table 4-3							
Documented	Occurrences of Spinner Dolphins at Us	Number					
Date	Location	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,	Outside SAR, along the reef	100					
2007							
February 23,	Oceanside, southwest of Kwajalein	36					
2007	Atoll						
March 1, 2007	Between Legan and Lone Palm	100					
May 3, 2007	South Pass	60					
May 3, 2007	Oceanside, off Kwajalein Golf	50					
	Course						
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					
Sources LISAE 2007	7						

Source: USAF 2007

Distribution. The rough-toothed dolphin is regarded as an offshore species that prefers deep water, but it can occur in waters of variable bottom depth. It rarely occurs close to land, except around islands with steep drop-offs near shore (Gannier and West 2005). In some areas, this species may frequent coastal waters and areas with shallow bottom depths (Lodi and Hetzel 1999; Ritter 2002). 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 specific 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. There are no known threats in the Action Area that are specific to only rough-toothed dolphins.

Populations in the Action Area.

<u>Broad Ocean Area</u>: While this species occurs in nearshore waters of the Hawaiian Islands, this species is not likely to occur in the BOA of the Action Area. 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).

<u>Vicinity of Illeginni Islet</u>: This species is not known to occur in the vicinity of Illeginni Islet. The roughtoothed 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 (NMFS 2015d). Calving seasons are likely timed in response to seasonally available local resources. Deep-sea fish in the stomachs of some offshore individual bottlenose dolphins suggest that they dive to more than 500 m (1,640 ft). Typical dives, however, are shallower and shorter.

The audiogram of the bottlenose dolphin shows that best sensitivity occurs near 50 kHz at a detection threshold level of about45 dB re 1 μ Pa (Nachtigall et al. 2000; Finneran and Houser 2006; Houser and Finneran 2006). Below the maximum sensitivity, thresholds increased (indicating less sensitivity) continuously up to a level of 137 dB re 1 μ Pa at 75 Hz; above 50 kHz, thresholds increased slowly up to a level of 55 dB re 1 μ Pa at 100 kHz, then increased rapidly above this to about 135 dB re 1 μ Pa 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). The full range of functional hearing is estimated to occur between approximately 75 Hz and 160 kHz, placing them among the group of cetaceans that can hear mid-frequency sounds (Southall et al. 2007).

Distribution. The bottlenose dolphin has a worldwide distribution ranging from latitudes of 45°N to 45°S. Bottlenose dolphins are found most commonly in coastal and continental shelf waters of tropical and temperate regions of the world. They occur in most enclosed or semi-enclosed seas, as well as in shallow, murky estuarine waters and deep, clear offshore waters in oceanic regions (Wells et al. 2009). 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). A Hawai'i pelagic stock is recognized, although little is known about their distribution. Although in most areas bottlenose dolphins do not migrate (especially where they occur in bays, sounds, and estuaries), seasonal shifts in abundance do occur in many areas (Griffin and Griffin 2004).

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. There are no known threats in the Action Area that are specific to only bottlenose dolphins.

Populations in the Action Area.

<u>Broad Ocean Area</u>: This species occur near shore in the Hawaiian Islands and the 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). While this species may occur in deeper waters, it is not likely to occur in the BOA of the Action Area.

<u>Vicinity of Illeginni Islet</u>: 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. Life history of Cuvier's beaked whale is not well known. There is no calving season known for this species (Jefferson et al. 2008). Cuvier's beaked whales, similar to other beaked whale species, are known to be deep divers. This species is a type of toothed whale, which typically feeds on fish found on the bottom or in mid-water, and on deep-sea squid found in water depths over 400 m (1,312 ft; Gannon et al. 1998). From anatomical examination of their ears, beaked whales are presumed to be predominantly adapted to best hear ultrasonic frequencies (MacLeod 1999). Beaked whales may be more sensitive than other cetaceans to low-frequency sounds (MacLeod 1999). The full range of functional hearing for beaked whales is estimated to occur between approximately 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. 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. There are no known threats in the Action Area that are specific to only Cuvier's beaked whales.

Populations in the Action Area.

<u>Broad Ocean Area</u>: 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.

<u>Vicinity of Illeginni Islet</u>: 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 is listed as endangered under the ESA and as depleted under the MMPA. This seal is one of only two remaining monk seal species which grows to 2.1 to 2.3 m (7.0 to 7.5 ft) and 170 to 204 kg (375 to 450 lbs; NMFS 2015d). Monk seals feed on a variety of prey including fish, cephalopods, and crustaceans in benthic areas of waters 18 to 90 m (60 to 300 ft) deep (NMFS 2015d). 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 late March and early April; however, births have been recorded year round (NMFS 2015d). Critical habitat was designated for this species in 1986 with revisions in 1988 and 2015 (Federal Register 80: 50925[August 21, 2015]). In the revised rule, critical habitat would include most waters around Hawaiian Islands out to a depth of 500 m (1,640 ft) with some excluded areas such as PMRF.

Distribution. Hawaiian monk seals live in subtropical waters surrounding atolls, islands, and submerged offshore reefs or banks. These seals spend an estimated two-thirds of their lives at sea (NMFS 2015d). 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 2015d). The entire range of the Hawaiian monk seal is within US waters on and near the NWHI. The majority of seals breed and pup on the northern Hawaiian Islands; however seals have given birth on all of the major islands of Hawai'i (NMFS 2015d). One seal tracked by satellite was observed traveling at least 700 km (378 nm) south-southwest of the main Hawaiian Islands (NMFS 2015d).

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).

Populations in the Action Area.

<u>Broad Ocean Area</u>: This species is known to occur on and near the Hawaiian Islands including Kauai. The current population of this species is approximately 1200 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 2015d).

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

4.2 Birds

One species of consultation seabird 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 (Federal Register 40:17590 [April 21, 1975]) and a recovery plan for Newell's shearwater was approved in February 1983 (USFWS 2011b). This 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. 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 food supply determines the marine distribution of seabirds.

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).

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 percent 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 (NMFS 2016). Studies on Kauai have documented abandonment of 3 of 8 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 to 10 percent 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.

<u>Broad Ocean Area</u>: The Newell's shearwater forages in BOA and offshore waters near breeding grounds where it feeds primarily on squid (NMFS, 2016). 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 (200nm) 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 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.

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

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

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

Sources: NMFS 2015d

E: Endangered, T:Threatened, D: Depleted, UES: UES protection (USASMDC/ARSTRAT 2014 Section3-4.5.1)

L-Likely; P – Potential; U – Unlikely

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). 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 (NMFS 2016). 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, 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.

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 USAG-KA 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, 1991).

Sea Turtle Hearing. Sea turtle auditory sensitivity is not well studied. The range of maximum sensitivity for sea turtles appears to be 200 to 800 Hz (Lenhardt 1994; Moein et al. 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. Because their anatomy is similar to that of green turtles, 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 distinct population segments 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 (Federal Register 76: 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. Polovina et al. (2006) found that juvenile loggerheads in the western North Pacific Ocean at times swim against currents because they are attracted to areas of abundant prey. These results suggest that the location of currents and associated frontal eddies are important to loggerhead foraging.

Distribution. The loggerhead turtle is found in temperate to tropical regions of the Atlantic, Pacific, and Indian oceans and in the Mediterranean Sea (NMFS 2016). 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 (nautical miles) 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.

Threats. North Pacific Ocean loggerheads have declined 50 to 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 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.

<u>Broad Ocean Area</u>: 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), their occurrence in the offshore waters of the Hawai`i portion of the BOA is believed to be rare. Loggerheads appear to use the entire North Pacific Ocean during development. There is substantial 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. The highest densities of loggerheads can be found just north of Hawai`i (Polovina et al. 2000).

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).

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 six 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.

<u>Broad Ocean Area</u>: Green turtles are found in inshore waters around the entire main Hawaiian Islands and Nihoa Island, where reefs, their preferred habitats for feeding and resting, are most abundant. More than 90 % of all green turtle breeding and nesting occurs at French Frigate Shoals in the NWHI, the largest nesting colony in the central Pacific Ocean. They are common in the oceanic zone surrounding the Hawaiian Islands; this area is frequently inhabited by adults migrating to the NWHI to reproduce during the summer and by ocean-dwelling turtles that have yet to settle into coastal feeding grounds of the main Hawaiian Islands. Farther offshore, green turtles occur in much lower numbers and densities (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.

<u>Vicinity of Illeginni Islet:</u> 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 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 USAG-KA is not a significant nesting area. Based on available information, NMFS and USFWS (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 USAG-KA, suitable nesting habitat (relatively open sandy beaches and seaward margins of herbaceous strand above tidal influence) for sea turtles was identified, and these areas were thoroughly surveyed on foot for nesting pits and tracks. 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 (Eder 2011). The nests were excavated after the eggs hatched, and the numbers of hatched and unhatched eggs were estimated as follows:

- Nest excavated on 9/2/2010: approximately 56 hatched eggs and 7 unhatched eggs.
- Nest excavated on 9/25/2010: approximately 65 to 70 hatched eggs and 1 unhatched egg.
- Nest excavated on 10/28/2010: approximately 93 hatched eggs, 3 partially hatched eggs, and 1 unhatched egg.

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, 1 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 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 (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.

4.3.3 Leatherback turtle (Dermochelys coriacea)

Species Description. The leatherback is listed as endangered as a single global population under the ESA. While preliminary genetic data may support separation into distinct population segments (NMFS and USFWS 2007d; TEWG 2007), this species is not 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 at the surface and in the water column (NMFS and USFWS 1992).

Distribution. Leatherback turtles are found in tropical to temperate regions of the Atlantic, Pacific, and Indian oceans (NMFS and USFWS 1992). Leatherbacks are able to tolerate colder water than other species and have the most extensive range of all sea turtles, from approximately 70° N to 45° S (Hughes et al. 1998). Leatherbacks occur mostly in the open ocean and are only occasionally found in coastal areas. There is evidence that leatherbacks are associated with oceanic front systems, such as shelf breaks and the edges of oceanic gyre systems, where their prey is concentrated (Eckert 1993). Upwelling areas, such as equatorial convergence zones, are nursery grounds for leatherback hatchlings and early juveniles because these areas provide abundant prey (Musick and Limpus 1997). Late juvenile and adult leatherback turtles are known to range from mid-ocean to the continental shelf, foraging closer to shore in temperate waters and more offshore in tropical waters (Grant and Ferrell 1993). Their movements appear to be linked to the seasonal availability of their prey and the requirements of their reproductive cycle (Collard 1990; Davenport and Balazs 1991). 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). 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. Causes for the decline in leatherback turtles include the nearly complete harvest of eggs and high levels of mortality during the 1980s, primarily in the high seas driftnet fishery, which is now banned (Chaloupka et al. 2004). 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.

<u>Broad Ocean Area</u>: 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 six % 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 distinct population segment 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). 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 live in the open ocean before settling into nearshore habitats as older juveniles. Juvenile and adult hawksbills are considered the "most coastal" of all sea turtles, preferring coral reef habitats (NMFS 2016). Reefs provide shelter for resting hawksbills day and night, and they are known to repeatedly visit the same resting areas. Hawksbills are also found around rocky outcrops and high-energy shoals—optimum sites for sponge growth—as well as mangrove-lined bays and estuaries (NMFS 2016). 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.

<u>Broad Ocean Area</u>: 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). 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). Effective recovery efforts are hampered by a lack of knowledge of their migration patterns, population size, and distribution (NMFS and USFWS 2007c).

<u>Vicinity of Illeginni Islet:</u> 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.

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;

• 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 (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 ridleys 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 suggests 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 on or near the seafloor, including snails, clams, tunicates, fish, fish eggs, crabs, oysters, sea urchins, shrimp, and jellyfish (Mortimer 1995; Polovina et al. 2004).

Distribution. The olive ridley is found in tropical waters of the south Atlantic, Pacific, and Indian oceans, generally between 30° N and 30° S. Both adults and juveniles occur primarily in open ocean habitats, though sightings are relatively rare (Zug et al. 2006). While these turtles occupy the neritic zone during the breeding season, turtles spend most of the non-breeding portions of their lives in the oceanic 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 (nautical miles) over vast oceanic areas (NMFS and USFWS 2014). Neither males nor females migrate to one specific foraging area but tend to roam and occupy a series of feeding areas in the open ocean (Plotkin et al. 1994). Although some of the largest nesting beaches occur along the Pacific coast of Central America, there are little data regarding its occurrence 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.

<u>Broad Ocean Area</u>: 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. 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). 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

Seven species of ESA candidate or proposed threatened fish have the potential to occur in the Action Area (Table 4-1 and Table 4-5). These include the bigeve thresher shark, oceanic whitetip shark, humphead wrasse, scalloped hammerhead shark, reef manta ray, oceanic giant manta ray, and Pacific bluefin tuna. The bigeve 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 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 possible that it would 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. 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.

Fish Presence in the Broad Ocean Area (BOA) and Near Illeginni Islet, Kwajalein Atoll.									
				Likelihood of Occurrence:					
Common Name	Scientific Name	ESA Listing Status	Protection Status	in the BOA	Near Illeginni Islet				
Bigeye thresher shark	Alopias superciliosus	-	UES	L	U				
Oceanic whitetip shark	Carcharhinus longimanus	РТ	UES	L	U				
Humphead wrasse	Cheilinus undulatus	-	UES	U	L				
Reef manta ray	Manta alfredi	-	UES	U	Р				
Oceanic giant manta ray	M. birostris	РТ	UES	Р	U				
Scalloped hammerhead shark	Sphyrna lewini	Т	UES	U	Р				
Pacific bluefin tuna	Thunnus orientalis	С	UES	Р	U				

Table 4-5

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

Sources: NMFS 2015d, IUCN 2015

PT: Proposed Threatened, T:Threatened, C:Candidate, UES: UES protection (USASMDC/ARSTRAT 2014)

L-Likely; P – Potential; U – Unlikely

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. 2004) 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 1500 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 μ Pa 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 that threshold guidelines of a peak exposure of 206 dB for physical injury of fish, a 189 dB sound exposure level 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 (Federal Register 81: 18979-19011 [April 1, 2016]). Though this species is not listed under the ESA it is currently protected under the UES (USASMDC/ARSTRAT 2016 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). The mating season for these sharks has not yet been identified and 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. 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). These sharks range in depth from the surface to 500m deep but are mostly found below 100 m (328 ft) deep (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. These sharks are also believed to move vertically in the water column throughout a day, feeding in deeper waters during the daylight hours and ascending to hunt as daylight dims (Defenders of Wildlife 2015a).

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 problems 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.

<u>Broad Ocean Area</u>: 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). Based on this shark's propensity for long distance migration and for feeding in deep waters, it is likely to occur in the BOA portion of the Action Area.

<u>Vicinity of Illeginni Islet</u>: 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 December 2016, NMFS proposed a rule to list the oceanic whitetip shark as a threatened species under the ESA (Federal Register 81:96304 [December 29, 2016]). The species is now an ESA Candidate species. This large, highly migratory shark usually swims at or near the water surface with their huge pectoral fins outspread (NMFS 2016). 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 (NMFS 2016). This viviparous shark typically gives birth to 1 to 14 pups every other year after a 10 to 12 month gestation period (NMFS 2016).

Distribution. The oceanic whitetip is a highly migratory species and is one of the most widespread shark species in tropical and subtropical water of the world (NMFS 2016). This species is typically found in waters between 30°N and 35°S latitude (NMFS 2016). The oceanic whitetip is found throughout the western and central Pacific Ocean where it is a surface-dwelling and predominantly oceanic-epipelagic (NMFS 2016). While these sharks may occasionally be found in coastal waters, these sharks are usually found far offshore in the open ocean (NMFS 2016). 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; NMFS 2016). 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 decline 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.

<u>Broad Ocean Area</u>: This species is known to occur in deeper oceanic waters near the Hawaiian Islands and near RMI (Defenders of Wildlife 2015c). While little is known about the distribution and abundance of these sharks in the BOA, some tagged sharks have been track 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).

<u>Vicinity of Illeginni Islet</u>: Even though the oceanic whitetip shark is known to occur in deep ocean waters of the RMI, 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 (Federal Register 78:13614 [February 28, 2013]). In September 2014, NMFS determined that ESA listing of the humphead wrasse was not warranted (Federal Register 79: 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 (1 to 8 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 depths from 1 to 100 m (3 to 330 ft; 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 more hard coral cover (Sadovy et al. 2004).

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.

<u>Vicinity of Illeginni Islet</u>: NMFS (2014) has reported that 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. Occurrence records of *C. undulatus* suggest a broad, but scattered distribution at USAG-KA with observations of adults recorded in seaward reef habitats at Illeginni (shallowest depths approximately 5 m (15 ft) deep (USFWS 2011a, USFWS and NMFS 2012). Although encountered on numerous occasions at USAG-KA, direct density measures of *C. undulatus* have not been obtained. The adults of this species may range very widely with typically 4 or less individuals observed within a broad spatial reef area (Dr. Robert Schroeder, National Marine Fisheries Service). Two neighboring seaward reef flat sites in 2008 were noted to have adult *C. undulatus* present (USFWS 2011a); thus, a total of 8 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, enhanced feeding (Randall et al. 1978), and/or displacement.

Table 4-6
Number of Survey Sites (2008 to present) with Observed UES Fish Consultation Species and
Occurrences at USAG-KA (KI = Kwajalein, RN = Roi Namur,
MK = Meck, OM = Omelek, EN = Ennylabegan, LG = Legan, IL = Illeginni, GA = Gagan,
GN = Gellinam, $EK = Eniwetak$, $ET = Ennugarret$, and MAC = Mid Atoll Corridor). ¹

Scientific Name	KI	RN	MK	OM	EN	LG	IL	GA	GN	EK	ET	MAC	Total
Labridae Cheilinus undulatus Mobulidae	4	1	-	2	1	0	1	3	1	0	1	3	17
$Manta \text{ sp.}^2$	2	0	0	0	0	0	0	0	0	0	0	0	2
No. Sites Surveyed	15	10	5	4	4	6	4	5	5	4	6	35	103

¹ Source: NMFS and USFWS 2013a.

 2 The 2010 inventory report lists *Manta birostris* for these observations. This taxa was recently (2009) split into two species and these nearshore observations may be of the species *Manta alfredi*.

Shallow inshore branching coral areas with bushy macro-algae, such as that which may exist along the shallow lagoon reef flat at Illeginni, 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).

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, 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-1 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 (Federal Register 82:3694-3715 [January 12, 2017]). Though this species is not listed under the ESA it is currently protected under the UES (USASMDC/ARSTRAT 2016 Section 3-4.5.1). Until 2009, all manta rays were considered a single species, *Manta birostris*. There are currently 2 species of manta ray, *M. alfredi* and *M. birostris*, as supported by morphological and genetic data (Marshall et al. 2011a). 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 one 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 (Marshall et al. 2011a). 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 (Marshall et al. 2011a).

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.

<u>Vicinity of Illeginni Islet</u>: Manta rays were observed during the 2010 inventory of Kwajalein Atoll islets (Table 4-6). While these observations at two locations near Kwajalein Islet were recorded as observations of *Manta birostris* (giant manta ray), it is likely that these nearshore observations were actually reef manta rays. The *Manta* genus was only recently revised to include the *M. alfredi* species. Prior to 2009, only *M. birostris* was recognized. 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 this species is known to occur in nearshore waters of Kwajalein Atoll, there are no known records of the species or of the *Manta* genus 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 2017, NMFS announced a 12-month finding on the petition to list the oceanic giant manta ray and proposed that this species be listed as a threatened species under the ESA (Federal Register 82: 3694-3715 [January 12, 2017]). Until 2009, all manta rays were considered a single species, *Manta birostris*. There are currently 2 species of manta ray, *M. alfredi* and *M. birostris*, as supported by morphological and genetic data (Marshall et al. 2011b). 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). This species has been tracked diving to depths exceeding 1,000m (3281 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). Major threats to this species include both targeted and bycatch fishing (Marshall et al. 2011b). 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).

Populations in the Action Area.

<u>Broad Ocean Area</u>: 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 for this species. While individuals may aggregate at cleaning or feeding sites, this species is rarely encountered in large numbers 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 (Defenders of Wildlife 2015b).

<u>Vicinity of Illeginni Islet</u>: This species is not known to occur in nearshore waters of Kwajalein Atoll, there are no known records of the species or of the *Manta* genus in the vicinity of Illeginni Islet. Manta rays were observed during the 2010 inventory of Kwajalein Atoll islets (Table 4-6). While these

observations at two locations near Kwajalein Islet were recorded as observations of *Manta birostris* (giant manta ray), it is likely that these nearshore observations were actually reef manta rays. The *Manta* genus was only recently revised to include the *M. alfredi* species. Prior to 2009, only *M. birostris* was recognized. 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.

4.4.6 Scalloped hammerhead (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, 6 distinct populations segments (DPSs) of the scalloped hammerhead shark were recognized (Federal Register 78: 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 (Federal Register 78: 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 (Federal Register 78: 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 from the surface and intertidal zones to depths of at least 275 m (900 ft). 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).

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), however, there are no data confirming their presence in the BOA. They are considered to be semi-oceanic and occur primarily in coastal areas; therefore, the possibility of their presence in the BOA is likely to be extremely low. Their scattered distribution in the western Pacific includes all of the tropical/temperate Pacific Islands (Baum et al. 2007). Fisheries exploitation is well documented in the Eastern Pacific, but there are no available data on threats specific to the BOA for this species.

Despite the abundance and circumglobal distribution of scalloped hammerheads, habitat preferences of these sharks in the open ocean are generally not well known.

<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 (M. Molina, Pers. Comm., 2014). This species may also occur in the vicinity of Illeginni Islet, but there are no available data on occurrence or threats to the species for this portion of the Action Area. Specific habitat preferences around Illeginni Islet are not known for scalloped hammerheads. These sharks have shown diel vertical movements in other areas. 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 % 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 miles [mi]) (Franks et al. 2009).

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 (Federal Register 81: 70074-70080 [October 11, 2016]). The NMFS is currently conducting a status review of this species to determine whether the listing under the ESA is warranted. 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 which 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. 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 to spawn (CBD 2016). These tuna 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 1000 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.

<u>Broad Ocean Area</u>: 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 (Federal Register 80: 70076). A NOAA (2015) summary report on the 2014 Hawai'i-based longline fisheries logbooks included only 2 bluefin tuna which were caught in an EEZ outside the US 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.

<u>Vicinity of Illeginni Islet</u>: 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 15 species of coral requiring consultation that have been found in the vicinity of Illeginni Islet since 2008 (Table 4-7) and an additional 4 consultation species that have the potential to occur in the Action Area. These species

include 2 coral species listed as ESA- threatened and 17 other corals, which were found to be unwarranted for ESA listing and subsequently eliminated from the NMFS listing proposal. However, these latter 17 species are still currently protected under the UES (Table 4-1). All of these species are also listed as vulnerable by the International Union for Conservation of Nature (IUCN 2015). The UES lists all corals species in Scleractinia as Species of Significant Biological Importance (SOSBI) as well as *Heliopora coerulea* (USASMDC/ARSTRAT 2016). Consequently, all consultation coral species are also listed as SOSBIs under the UES (Table 4-1). All of these species are also regulated by Appendix II of CITES (2011).

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 subhabitat 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 long-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; Gochfeld 2004; Gulko 1998). The crown of thorns sea stars (*Acanthaster planci*) are the primary predators of most ESA-listed and SOSBI 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. Reproductive strategies in corals are not well defined (Fautin 2002). Most of the shallow-water species requiring consultation in Table 4-1 reproduce 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 fragmentation. This 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 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 on a scale of tens of kilometers occurs much more frequently than long-distance dispersal (Jones et al. 2009; Mumby and Steneck 2008). Less frequent long-distance dispersal is more commonly associated with spawning corals, and it is these buoyant eggs and planktonic larvae (typically free-swimming planulae) that are more likely to be found in open ocean areas. 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. Altogether this suggests that gametes and planulae will be found in the open ocean, but this is the smaller fraction of the total pool of gametes, planulae, and larvae.

Coral planulae density in the water directly over the reef is zero except during reproduction when density peaks at 1,600 per 100 cubic meter (m³; 3,531 cubic feet [ft³]) for brooding species to 16,000 per 100 m³ (3,531 ft³) for spawning species (Hodgson 1985). On the Great Barrier Reef, similar densities of coral larvae directly over the reef rapidly dispersed by 3 to 5 orders of magnitude in waters 5 km (3.1 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 the colony is established (one or two 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, 2011a, 2011b; USFWS 2011a).

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 reefassociated 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 m³ (per 35.31 ft³) in waters 5 km (2.7 nm) away from the reef, and 1.6 per m³ (0.05 per ft³; brooding species) to 16 per m³ (0.45 per ft³; 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 USAG-KA 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 14 species of coral requiring consultation that have been found in the vicinity of Illeginni Islet since 2008 (Table 4-7). Three of these species, *Acropora tenella, A. vaughani, 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. 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, although recently described species such as *Acropora rongelapensis* may prove to be endemic (Richards and Wallace 2004). On a provincial scale, 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) and at other locations in the Marshall Islands (Beger et al. 2008; Pinca et al. 2002; USFWS and NMFS 2011b). 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. The shallow seaward reef on the northwestern side of Illeginni Islet appears somewhat degraded, relative to analogous areas at other USAG-KA islets (USFWS and NMFS 2006). Herbivorous invertebrates, such as sea urchins, are noticeably absent; although herbivorous reef fishes are generally abundant and the scars on the substrate indicate that they feed in this area. Suspended sediment in the water column is common in this area. Whatever the underlying causes are, it is evident that ecological functions are reduced on the shallow northwestern seaward reef of Illeginni (USFWS and NMFS 2002, 2004, 2006).

Table	4-7
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Number of Survey Sites (2008 to present) with Observed Coral Consultation Species Occurrences at USAG-KA (KI = Kwajalein, RN = Roi Namur, MK = Meek, OM = Omelek, EN = Ennylabegan, LG = Legan, IL = Illeginni, GA = Gagan, GN = Gellinam, EK = Eniwetak, ET = Ennugarret) and Mid-Atoll Corridor (MAC).¹

Scientific Name	KI	RN	MK	ОМ	EN	LG	IL	GA	GN	EK	ET	MAC	Total	# of Islets
Acanthastrea brevis	1	1	1	-	-	-	2	2	-	1	-	23	31	6
Acropora aculeus	2	-	-	-	1	1	1	-	-	-	-	3	8	4
A. aspera	6	3	1	1	-	-	-	-	-	-	2	1	14	5
A. dendrum	5	-	3	1	-	1	1	1	1	-	-	5	18	7
A. listeri	-	1	-	-	-	1	-	1	-	1	-	2	6	4
A. microclados	11	1	4	2	4	6	4	3	4	4	1	34	78	11
A. połystoma	1	1	-	-	-	-	-	-	-	-	-	1	3	2
A. speciosa	1	-	-	-	-	-	-	-	-	-	-	4	5	1
A. tenella	5	-	-	-	-	-	1	-	-	-	-	1	7	2
A. vaughani	3	-	-	1	-	-	1	1	2	1	2	4	15	7
Alveopora verilliana	2	1	-	-	-	1	2	-	-	-	-	10	16	4
Cyphastrea agassizi	1	1	1	-	-	-	2	1	1	2	-	14	23	7
Heliopora coerulea	1	2	2	1	2	6	4	2	3	4	1	32	60	11
Leptoseris incrustans	1	1	-	-	-	1	-	1	2	1	-	25	32	6
Montipora caliculata	1	1	4	1	-	4	4	3	3	4	1	31	57	10
Pavona cactus	8	1	4	1	-	-	1	2	-	-	3	4	24	7
P. venosa	7	2	1	1	3	2	1	3	1	1	1	16	39	11
Turbinaria reniformis	1	3	-	-	-	-	3	3	2	2	-	9	23	6
T. stellulata	-	1	-	-	-	1	2	2	1	-	1	9	17	6
Total No. Sites Surveyed	15	5	5	4	4	6	4	5	5	4	3	35	95	11

¹Sources: NMFS and USFWS 2013, NMFS-PIRO 2014a.

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 2016 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 (Center for Biological Diversity 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.

<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 above.

<u>Vicinity of Illeginni Islet</u>: Acanthastrea brevis has been observed at 6 of the 11 Kwajalein Atoll islets since 2008. In addition to Illeginni, 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 33% (31 of 95) of survey sites in Kwajalein Atoll. This species was observed at 50% (2 of 4) of sites at Illeginni Islet since 2008 (Table 4-7).

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 2016 Section 3-4.5.1). This species in the family Acropridae 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 (Center for Biological Diversity 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 (Center for Biological Diversity 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.

<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 above.

<u>Vicinity of Illeginni Islet</u>: Acropora aculeus has been observed at 4 of the 11 Kwajalein Atoll islets since 2008. In addition to Illeginni, it has been observed during inventories at Kwajalein, Ennylabegan,

and Legan islets as well as on reefs in the Mid-Atoll Corridor. Overall, *A. aculeus* has been observed at 8% (8 of 95) survey sites in Kwajalein Atoll. This species was observed at 25% (1 of 4) of sites at Illeginni Islet since 2008 (Table 4-7).

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 2016 Section 3-4.5.1). This species in the family Acropridae 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 (Center for Biological Diversity 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 (Center for Biological Diversity 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.

<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 above.

<u>Vicinity of Illeginni Islet</u>: Acropora aspera has been observed at 5 of the 11 Kwajalein Atoll islets since 2008. This species was not observed at Illeginni islet; however, it has been observed during inventories at Kwajalein, Roi Namur, Meck, Omelek, and Ennugarret islets as well as on reefs in the Mid-Atoll Corridor. Overall, *A. aspera* has been observed at 15% (14 of 95) survey sites in Kwajalein Atoll (Table 4-7).

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 2016 Section 3-4.5.1). This species in the family Acropridae 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 (Center for Biological Diversity 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 (Center for Biological Diversity 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.

<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 above.

<u>Vicinity of Illeginni Islet</u>: Acropora dendrum has been observed at 7 of the 11 Kwajalein Atoll islets since 2008. In addition to Illeginni, it has been observed during inventories at Kwajalein, Meck, Omelek, Legan, Gagan, and Gellinam islets as well as on reefs in the Mid-Atoll Corridor. Overall, *A. dendrum* has been observed at 19% (18 of 95) survey sites in Kwajalein Atoll. This species was observed at 25% (1 of 4) of sites at Illeginni Islet since 2008 (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 2016 Section 3-4.5.1). This species in the family Acropridae 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 (Center for Biological Diversity 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 (Center for Biological Diversity 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.

<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 above.

<u>Vicinity of Illeginni Islet</u>: Acropora listeri has been observed at all 4 of the Kwajalein Atoll islets and on reefs in the Mid-Atoll Corridor since 2008. While the species has not been observed at Illeginni islet, it has been observed near Roi Namur, Legan, Gagan, and Eniwetak islets. Overall, *A. listeri* has been observed at 4% (4 of 103) survey sites in Kwajalein Atoll (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 2016 Section 3-4.5.1). This species in the family Acropridae 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 think at their bases (Center for Biological Diversity 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 (Center for Biological Diversity 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.

<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 above.

<u>Vicinity of Illeginni Islet</u>: Acropora microclados has been observed at all 11 of the Kwajalein Atoll islets and on reefs in the Mid-Atoll Corridor since 2008. Overall, *A. microclados* has been observed at 82% (78 of 95) survey sites in Kwajalein Atoll. This species was observed at 100% (4 of 4) of sites at Illeginni Islet since 2008 (Table 4-7).

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 2016 Section 3-4.5.1). This species in the family Acropridae 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 (Center for Biological Diversity 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 (Center for Biological Diversity 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 above.

<u>Vicinity of Illeginni Islet</u>: Acropora polystoma has been observed at 2 of the 11 Kwajalein Atoll islets and on reefs in the Mid-Atoll Corridor since 2008. Though not observed during surveys at Illeginni islet, this species has been observed near Kwajalein and Roi Namur islets. Overall, *A. polystoma* has been observed at 2% (2 of 103) 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 Acropridae has cream-colored colonies consisting of thick cushions and bottlebrush branches with contrasting corallite tips (Center for Biological Diversity 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 (Center for Biological Diversity 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 is 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.

<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 above.

<u>Vicinity of Illeginni Islet</u>: Acropora speciosa has been observed at 1 of the 11 Kwajalein Atoll islets since 2008; Kwajalein islet and has also been observed at sites in the Mid-Atoll Corridor. Overall, *A. speciosa* has been observed at only 5% (5 of 95) survey sites in Kwajalein Atoll. This species was not observed at biennial survey sites at Illeginni Islet since 2008. However, 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 Acropridae has colonies consisting of horizontal plates or flattened branches with white or blue tips that either fan out or form irregular tangles (Center for Biological Diversity 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 (Center for Biological Diversity 2009). Acropopra 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.

<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 above.

<u>Vicinity of Illeginni Islet</u>: Acropora tenella has been observed at 2 of the 11 Kwajalein Atoll islets since 2008. In addition to Illeginni, 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* 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.

4.5.10 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 2016 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 (Center for Biological Diversity 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 (Center for Biological Diversity 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.

<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 above.

<u>Vicinity of Illeginni Islet</u>: Acropora vaughani has been observed at 7 of the 11 Kwajalein Atoll islets since 2008. In addition to Illeginni, it has been observed during inventories at Kwajalein, Omelek, Gagan, Gellinam, Eniwetak, and Ennugarret islets as well as on reefs in the Mid-Atoll Corridor. Overall, *A. vaughani* has been observed at 16% (15 of 95) survey sites in Kwajalein Atoll. This species was observed at 25% (1 of 4) of sites at Illeginni Islet since 2008 (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.

4.5.11 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 2016 Section 3-4.5.1). This species in the family Poritidae 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 (Center for Biological Diversity 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 (Center for Biological Diversity 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 above.

<u>Vicinity of Illeginni Islet</u>: Alveopora verrilliana has been observed at 4 of the 11 Kwajalein Atoll islets since 2008. In addition to Illeginni, it has been observed during inventories at Kwajalein, Roi Namur, and Legan islets as well as on reefs in the Mid-Atoll Corridor. Overall, *A. verrilliana* has been observed at 17% (16 of 95) survey sites in Kwajalein Atoll. This species was observed at 50% (2 of 4) of sites at Illeginni Islet since 2008 (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 2016 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 (Center for Biological Diversity 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 (Center for Biological Diversity 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.

<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 above.

<u>Vicinity of Illeginni Islet</u>: Cyphastrea agassizi has been observed at 7 of the 11 Kwajalein Atoll islets since 2008. In addition to Illeginni, it has been observed during inventories at Kwajalein, Roi Namur, Meck, Gagan, Gellinam, and Eniwetak islets as well as on reefs in the Mid-Atoll Corridor. Overall, *C. agassizi* has been observed at 24% (23 of 95) survey sites in Kwajalein Atoll. This species was observed at 50% (2 of 4) of sites at Illeginni Islet since 2008 (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 2016 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 (Center for Biological Diversity 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 (Center for Biological Diversity 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 (Center for Biological Diversity 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.

<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 above.

<u>Vicinity of Illeginni Islet</u>: Heliopora coerulea has been observed at all 11 of the Kwajalein Atoll islets since 2008 as well as on reefs in the Mid-Atoll Corridor. Overall, *H. coerulea* has been observed at 63% (60 of 95) survey sites in Kwajalein Atoll. This species was observed at 100% (4 of 4) of sites at Illeginni Islet since 2008 (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 2016 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 (Center for Biological Diversity 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 (Center for Biological Diversity 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.

<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 above.

<u>Vicinity of Illeginni Islet</u>: Leptoseris incrustans has been observed at all 6 of the 11 Kwajalein Atoll islets since 2008. This species was found at Kwajalein Islet, Roi Namur, Legan, Gagan, Gellinam, and Eniwetak as well as in the Mid-Atoll Corridor. Overall, *L. incrustans* has been observed at 31% (32 of 95) survey sites in Kwajalein Atoll (Table 4-7). This species was not observed during biennial surveys at Illeginni Islet since 2008.

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 2016 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 (Center for Biological Diversity 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 (Center for Biological Diversity 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 (Center for Biological Diversity 2009). Like other species in the *Montipora* genus, it is also vulnerable to heavy harvest levels (Center for Biological Diversity 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.

<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 above.

<u>Vicinity of Illeginni Islet</u>: Montipora caliculata has been observed at 10 of the 11 Kwajalein Atoll islets since 2008. In addition to Illeginni, it has been observed during inventories at Kwajalein, Roi Namur, Meck, Omelek, Legan, Gagan, Gellinam, Eniwetak, and Ennugarret islets as well as on reefs in the Mid-Atoll Corridor. Overall, *M. caliculata* has been observed at 60% (57 of 95) survey sites in Kwajalein Atoll. This species was observed at 100% (4 of 4) of sites at Illeginni Islet since 2008 (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 2016 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 (Center for Biological Diversity 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 (Center for Biological Diversity 2009). This species s 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.

<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 above.

<u>Vicinity of Illeginni Islet</u>: Pavona cactus has been observed at 7 of the 11 Kwajalein Atoll islets since 2008. In addition to Illeginni, it has been observed during inventories at Kwajalein, Roi Namur, Meck, Omelek, Gagan, and Ennugarret islets as well as on reefs in the Mid-Atoll Corridor. Overall, *Pavona cactus* has been observed at 25% (24 of 95) survey sites in Kwajalein Atoll. This species was observed at 25% (1 of 4) of sites at Illeginni Islet since 2008 (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 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 2016 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 (Center for Biological Diversity 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 (Center for Biological Diversity 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.

<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 above.

<u>Vicinity of Illeginni Islet</u>: Pavona venosa has been observed at all 11 of the Kwajalein Atoll islets since 2008 as well as in the Mid-Atoll Corridor. Overall, *P. venosa* has been observed at 41% (39 of 95) survey sites in Kwajalein Atoll. This species was observed at 25% (1 of 4) of sites at Illeginni Islet since 2008 (Table 4-7).

4.5.18 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 2016 Section 3-4.5.1). This species in the family Dendrophyllidae is a yellow-green coral with contrasting colored margins (Center for Biological Diversity 2009). *Turbinaria reniformis* colonies form large stands on fringing reefs where water is turbid and unifacial laminae sometimes form horizontal tiers (Center for Biological Diversity 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 (Center for Biological Diversity 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 (Center for Biological Diversity 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.

<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 above.

<u>Vicinity of Illeginni Islet</u>: Turbinaria reniformis has been observed at 6 of the 11 Kwajalein Atoll islets since 2008. In addition to Illeginni, it has been observed during inventories at Kwajalein, Roi Namur, Gagan, Gellinam, and Eniwetak islets as well as on reefs in the Mid-Atoll Corridor. Overall, *T. reniformis* has been observed at 24% (23 of 95) survey sites in Kwajalein Atoll. This species was observed at 75% (3 of 4) of sites at Illeginni Islet since 2008 (Table 4-7).

4.5.19 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 2016 Section 3-4.5.1). This species in the family Dendrophyllidae 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 (Center for Biological Diversity 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 (Center for Biological Diversity 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 (Center for Biological Diversity 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.

<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 above.

<u>Vicinity of Illeginni Islet</u>: Turbinaria stellulata has been observed at 6 of the 11 Kwajalein Atoll islets since 2008. In addition to Illeginni, it has been observed during inventories at Roi Namur, Legan, Gagan, Gellinam, and Ennugarret islets as well as on reefs in the Mid-Atoll Corridor. Overall, *T. stellulata* has been observed at 18% (17 of 95) survey sites in Kwajalein Atoll. This species was observed at 50% (2 of 4) of sites at Illeginni Islet since 2008 (Table 4-7).

4.6 Mollusks (Phylum Mollusca)

There are two mollusk species that require consultation in the Action Area: the commercial top shell snail and the black-lipped pearl oyster (Table 4-8). The commercial top shell snail (*Trochus 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 of deep ocean waters. 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 m³ (per 35.31 ft³) in waters 5 km (2.7 nm) away from the reef, and 1.6 per m³ (0.05 per ft³; brooding species) to 16 per m³ (0.45 per ft³; spawning species) in waters directly over the reef during reproduction (Hodgson 1985). Because of the relatively large distances between reefs and the BOA, overall larval density in the BOA is likely to be much lower. However, eggs and larvae are not homogenously distributed and 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 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 USAG-KA 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. Both the black-lipped pearl oyster and the commercial top shell snail have been observed in the vicinity of Illeginni islet. Adults of these two species have been observed on biennial inventories of the area, and the offshore waters also may support planktonic larvae of mollusks as discussed above.

4.6.1 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 hermaphroditic adults that first develop as male and then as females. Eggs and sperm are broadcast into the water where fertilization takes place.

Distribution. The black-lipped pearl oyster is found on reef habitats throughout the tropical Indo-Pacific. It is typically found shallower than 8 m (25 ft) but occurs at least as deep as 15 m (50 ft; Keenan et al. 2006). Although *Pinctada margaritifera* are occasionally found in the low intertidal zone and can tolerate brief aerial exposure, they are generally found at subtidal depths. These animals typically spawn bimonthly (Nair 2004). 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. *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.

<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 mollusk occurrence in the BOA in section 4.6 above.

<u>Vicinity of Illeginni Islet</u>: Pinctada margaritifera was observed at 8 of the 11 Kwajalein Atoll islets (Table 4-8). In addition to Illeginni, it was found at Kwajalein, Roi Namur, Omelek, Gagan, Gellinam, Eniwetak, and Ennugarret islets. Since 2008, *Pinctada margaritifera* individuals have been observed at 20 of 103 survey sites throughout Kwajalein Atoll including 1 of 4 survey sites on the reef slopes at Illeginni islet, during biennial inventories (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.

Table 4-81

Number of Survey Sites (2008 to present) with Observed Mollusk Consultation Species Occurrences at USAG-KA (KI = Kwajalein, RN = Roi Namur, MK = Meck, OM = Omelek, EL = Ennylabegan, LG = Legan, IL = Illeginni, GA = Gagan, GL = Gellinam, EK = Eniwetak, ET = Ennugarret, and MAC = Mid-Atoll Corridor).

Scientific Name	KI	RN	MK	OM	EL	LG	IL	GA	GL	ΕK	ΕT	MAC	Total
Pteriidae													
Pinctada margaritifera	7	2	-	2	-	-	1	2	1	2	3	-	20
<u>Tegulidae</u>													
Trochus niloticus ¹	10	6	3	4	4	6	4	2	3	1	4	12	59
No. Sites Surveyed	15	10	5	4	4	6	4	5	5	4	6	35	103

Source: NMFS and USFWS 2013.

¹Within RMI legislation *Trochus niloticus* is inclusive of *Trochus maximus*, *Tectus niloticus, and Tectus maximus*. Most biological authorities synonymize all of these under the name *Trochus niloticus*.

4.6.2 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 *Trochus niloticus*, a consultation species, is inclusive of *Trochus maximus*, *Tectus niloticus*, and *Tectus maximus*. Most biological authorities synonymize all of these under the name *Trochus 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, *Trochus 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 and veligers of *Trochus niloticus* are free-swimming for at least 3 to 5 days. All members of this snail family are herbivores and occasionally detritivores.

Distribution. *Trochus niloticus* occupies intertidal and shallow subtidal zones on the seaward margin of reefs at depths up to 27 m (89 ft). *Trochus 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 *Trochus 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 Tridacnidae 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.

<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 mollusk occurrence in the BOA in section 4.6 above.

<u>Vicinity of Illeginni Islet</u>: Trochus niloticus was observed at all 11 of the Kwajalein Atoll islets as well as on reefs in the Mid-Atoll Corridor (Table 4-8). *Trochus 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).

5.0 EFFECTS OF THE ACTION

This section examines the ways in which the FE-1 flight may directly and indirectly affect cetacean, phocid, sea turtle, fish, coral and mollusk consultation species in the Action Area. The potential direct and indirect effects of the FE-1 flight on the aforementioned species and their habitats in each of the three portions of the Action Area are analyzed. The potential effects of five general types of FE-1 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 three portions of the Action Area: BOA, deep ocean waters near Kwajalein Atoll, and at Illeginni Islet.

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 and any pre- and post-test operations would only extend to depths of approximately 30.5 m (100 ft). Because effects for FE-1 related stressors are greatest at or near the surface, the discussion of the effects of stressors will 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 beneficial effect; no effect; may affect but not likely to adversely affect; or 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-1 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).

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 disturb a marine mammal stock in the wild; or (ii) any act that disturbs or is likely to disturb a 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 sound pressure levels 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.

Sound creates vibrations that travel through air or water. Sound vibrations are characterized by their frequency (generally expressed in Hertz [Hz]) and amplitude or loudness which is quantified here using the logarithmic dB. In water, sound pressure levels (SPL) are typically referenced to a baseline of 1 μ Pa whereas in-air pressures are typically referenced to 20 μ Pa. In-air pressure measurements are converted to in-water estimates. Unless noted, all in-water sound pressure levels in the following analyses all dB levels presented below assume dB re 1 μ Pa. For many organisms it can be useful to distinguish between peak exposure levels (dB_{peak}) and total exposure over time (sound exposure level [SEL]). For some organisms, effects are compared to thresholds based on the root mean square (RMS) sound pressure level 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 vehicle booster 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-1 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 below shows sonic boom sound pressure levels at various stages during the trajectory.

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

The sonic boom will propagate up-range from the launch site and extend downrange along the entire flight path. The FE-1 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.

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-1 flight path, affected areas for sonic booms were calculated at various acoustic intensities (dB re 1 μ Pa (Appendix A). Approximately 1 km² (0.4 mi²) of ocean surface would be exposed to SPLs up to 170 dB, 54 km² (21 mi²) to SPLs up to 160 dB, and 338 km² (131 mi²) to SPLs up to 150 dB. Assuming an "N-Wave" sonic boom, a wide range for frequencies at various pressure levels are 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 109 dB re 20 μ Pa in the BOA and would be no greater than 149 dB re 20 μ Pa near payload impact at Illeginni Islet.

Splashdown of Spent Rocket Motors and other Vehicle Components. Elevated sound pressure levels 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 130 and 2,778 km (70 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 approximately 500 km (270 nm) from the third stage impact.

Estimates of splashdown forces and associated sound pressure levels for FE-1 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 inwater (at the surface) SPLs in dB re 1 μ Pa. The frequency of stage impacts is estimated to range from 100 Hz to 4 kHz (see Appendix A for stage impact power spectrum).

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

Table 5-2

Sources: Appendix A

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

Range to Threshold
$$(m) = 10^{\binom{dB_{source}-dB_{threshold}}{x}}$$

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 sound pressure levels 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 sound pressure levels in-air of 140 dB re 20 μ Pa at 18 m (59 ft; Navy personal communication 2016). 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 sound pressure levels in the shallow waters surrounding Illeginni. Using the cylindrical spreading model for shallower waters and an in-water SL of 191 dB, sound pressure levels may be above 160 dB out to 117m (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, a 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 sound pressure level and duration of exposure. As a sound gets louder, the duration required to induce threshold shifts gets shorter (National Research Council 2005).

Another common effect of elevated sound pressure levels 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. Such responses as sudden diving, change in swim speed, and change in respiration rate can have an effect on foraging and can decrease the foraging efficiency of various species. A disruption in foraging, or a reaction that forces an animal to expend energy diving or fleeing, may also affect the animal's energy budget (energy income against expenditure), with the outcome of less energy available for important biological functions. Responses can also include changes in the type or timing of an animal's vocalizations and masking of sounds produced from the impacted individual or from other individuals of the same species in the area such that those near the sound source will not hear those calls. Marine mammals have been observed to decrease their vocalizations in response to noise (Aguilar de Soto 2006; IWC 2007), which can have further implications on breeding, feeding, and social interacting.

Interpreting the effects of noise on marine mammals, birds, sea turtles, and fish depends on various parameters, including the sound exposure level and duration, the sound frequency, and the animals 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 uPa 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 sound exposure level (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 μ Pa²-s; US Navy 2015a). This assumes that the SPL is held constant. Since the duration of the SPLs are unknown, we use 1 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 "Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing" (NOAA 2016). The current thresholds depend on the hearing ability of marine mammals where cetaceans are separated into low-frequency, mid-frequency, and high-frequency groups (Table 5-3). The revised thresholds use both peak sound pressure levels (SPL_{peak}) and accumulated sound exposure levels (SEL_{cum}; NOAA 2016). Since elevated sound pressure levels for the FE-1 flight are very short in duration, we use peak exposure levels to estimate the effects of the pressures on consultation organisms (Table 5-4). Since the revised acoustic threshold criteria used by NMFS (NOAA 2016) 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).

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				
	Pacific white-sided dolphin	Lagenorhynchus obliquidens				
	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				

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

Sources: NOAA 2016

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.

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 2016

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 \geq 212 dB and \geq 218 dB, respectively (NOAA 2016; 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.

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).

If a seabird were exposed to elevated sound pressure levels 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 Navy's current standard of analysis uses a PTS threshold of 110 A-weighted decibels (dBA) re 20 μ Pa for continuous sounds and 140 dB re 20 μ Pa 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 1μ Pa/sec, a barotrauma threshold of 36 Pa/sec, and a mortality threshold of 138 Pa/sec (NMFS 2015a).

Behavioral response to elevated sound pressure levels 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 affects 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 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). 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 sound pressure levels 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 µPa²s (Finneran and Jenkins 2012). This threshold is based on studies that indicate that behavioral disturbance in may occur with SPLs of 175 to 179 dB re 1 μ Pa (which correspond to SELs of 163.6 to 160.4 dB re 1 μ Pa²s (Finneran and Jenkins 2012).

Potential Effect	Threshold	
Mortality/Mortal Injury	237 dB _{peak}	
Non-lethal Injury	230 dB _{peak}	
TTS	224 dB _{peak}	

160 dB SEL_{cum}

Table 5-5 Acous tles.

Source: Finneran and Jenkins 2012

Behavioral Disruption

Fish. While little is known about the specific hearing capabilities of the 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 1500 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 sound pressure levels can vary depending on the size of the fish, the presence of a swim bladder, and the fishes 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 are reminiscent of those produced by struggling prey (Myrberg 2001).

The effects of elevated sound levels on fish are evaluated using the current conventional threshold levels 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. 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 nonlethal 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.

mesholds for Thysical mjury and Denavioral Distupt							
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							

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

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 three is some evidence of 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). Acute and temporary acoustic exposures such as those associated with FE-1 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 irrelevant for the consultation corals and mollusks.

5.1.1.3 Estimation of Elevated Sound Level Effects

If consultation organisms were exposed to elevated sound pressure levels 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.

Sonic Booms. As discussed above, the FE-1 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 is135 dB (in-water) with a duration of approximately 0.27 seconds. 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 180 dB (in water) and last approximately 0.075 seconds for the loudest sounds and 0.27 seconds 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 54 km² (20.9 mi²) 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 338 km² (130.5 mi²) near the payload impact point. An estimated maximum of 21 green turtles and 7 hawksbill turtles may be exposed to SPLs high enough to elicit behavioral response (Table 5-9, 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 km². 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 animals are expected to return to their normal behavior within minutes of exposure. For these reasons, the effects of sonic booms on consultation organisms in 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 fish or birds.

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 Mammal Density Database (Hanser et al. 2013). Animal density shapefiles in the Marine Mammal 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 shapefiles did not cover motor impact zone 3, maximum density values were interpreted from density model maps in Hanser et al. (2013). 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. 2013). 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. 2013). 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. The chance of animal being affected by splashdown of spent FE-1 vehicle components in the BOA was calculated by the formula:

Number of Exposures = Species Density per km^2 x Affect Area in km^2

For payload impact at Illeginni Islet, sounds may propagate into the marine environment and a similar calculation was used number of exposures in this area. Data on sea turtle density in or near the Illeginni Islet are sparse and no reliable density data are available for the species in areas addressed in this BA. Since the Navy's Marine Mammal Density Database does not extend to areas of Kwajalein Atoll, green and hawksbill sea turtle density estimates where derived from literature sources in an attempt to better reflect the density of sea turtles near Illeginni Islet. Density data for green and hawksbill sea turtles from US Navy surveys in the Mariana Islands are available. As near Kwajalein Atoll, green turtles are by far the most abundant sea turtle throughout the Marianas archipelago (US Navy 2015a). The US Navy has reported the density of green sea turtles at Guam to be 1 per 3.4 km² (1 per 1.3 mi²) in offshore waters and 1 per 2.6 km² (1 per 0.988 mi²) in nearshore waters; and the density of hawksbill sea turtles at Tinian to be 1 per 7.5 km² (1 per 2.88 mi²; US Navy 2015a). 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.

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 marine mammals and sea turtles based on the calculated SPLs for each component (Table 5-7 and Section 5.1.1.1 above) and thresholds for each species group (section 5.1.1.2 above). 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 below). 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 affect estimates for the Proposed Action and are likely overestimates.

		Criterion	Radial Distance from Spent Motor Impact Point, m (ft)						
Species Group	Effect Category	(re 1 µPa)	Stage 1	Stage 2	Nose Fairing	Stage 3			
High	PTS (non-lethal injury)	202 dB _{peak}	6.3 (20.7)	1.4 (4.6)	-	-			
Frequency Cetaceans	TTS	$196 \text{ dB}_{\text{peak}}$	12.6 (41.3)	2.8 (9.2)	1 (3.3)	1.8 (5.8)			
Mid	PTS (non-lethal injury)	$230 \text{ dB}_{\text{peak}}$	-	-	_	-			
Frequency Cetaceans	TTS	$224 \ dB_{peak}$	-	-	-	-			
Low	PTS (non-lethal injury)	219 dB _{peak}	-	-	-	-			
Frequency Cetaceans	TTS	$213 \; dB_{peak}$	1.7 (5.8)	-	-	-			
D1 ¹	PTS (non-lethal injury)	218 dB _{peak}	1 (3.3)	-	-	-			
Fliocids	TTS	$212 \text{ dB}_{\text{peak}}$	2 (6.5)	-	-	-			
Birds	PTS (non-lethal injury)	212 dB SEL re 1 μPa²-s	2 (6.5)	-	-	-			
	Mortality/ Mortal Injury	237 dB _{peak}	-	-	-	-			
Seo Turtles	PTS (non-lethal injury)	$230 \text{ dB}_{\text{peak}}$	-	-	_	-			
Sea Turnes	TTS	$224 \text{ dB}_{\text{peak}}$	-	-	-	-			
	Behavioral Disruption	160 dB _{peak}	794 (2,606)	178 (583)	63.1 (207)	112 (368)			
	Mortality/ Mortal Injury	$229 \text{ dB}_{\text{peak}}$	-	-	-	-			
Fish	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 5-7 Maximum Underwater Radial Distances and Acoustic Affect Areas for Marine Mammals, Sea Turtles, and Fish from FE-1 Component Splashdowns in the BOA.

While the payload impact will be on land at Illeginni Islet, sounds may propagate into the water. The peak SPL for payload impact 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.

Table 5-8 Estimated Radial Distances and Acoustic Affect Areas for Marine Mammals, 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)		

<u>Results.</u> 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).

No temporary or permanent physical effects as a result of elevated sound levels are expected for midfrequency cetaceans for any portion of the Action Area as source levels do not exceed effect thresholds for these species. For low frequency cetaceans, elevated sound levels only exceed the TTS threshold for splashdown of the spent stage 1 motor. There is a 1 in 2.1×10^7 to 1 in 2.0×10^9 chance (depending on the species) of a low-frequency cetacean being exposed to SPLs great enough to cause TTS. High frequency cetacean species have a slight risk of being effected by elevated sound pressure levels from splashdown of FE-1 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. Overall, there is a 1 in 1.07×10^6 to 2.62×10^6 chance that a high-frequency cetacean will be exposed to SPLs high enough to elicit PTS and a 1 in 261,327 to 1 in 641,195chance of TTS exposure (Table 5-9).

It is important to remember that the model also does not account for animal movement or avoidance behaviors. Since cetaceans are highly mobile, they may be able to detect and avoid approaching vehicle components to some extent. 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 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, any behavioral effects would likely be less than those for sea turtles.

Hawaiian monk seals have a similarly low chance of being affected physically by the elevated SPLs generated by falling FE-1 components. 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 1 in 1.06×10^{10} for PTS effects and 1 in 2.67×10^{9} for TTS effects for Hawaiian monk seals.

Splashdown of FE-1 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 5 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.

5.0 Effects of the Action

 Table 5-9.

 Number of Marine Mammal and Sea Turtle Exposures to Acoustic Impacts from FE-1 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	-	-	-	0.00572	-	-	-	-	4.20E-08	-
B. borealis	0.00016	-	1.59E-09	-	0.00016	-	-	-	0.00019	-	-	-	-	1.59E-09	-
B. edeni	0.00012	-	1.18E-09	-	0.00016	-	-	-	0.00015	-	-	-	-	1.18E-09	-
B. musculus	0.00005	-	4.97E-10	-	0.00005	-	-	-	0.00082	-	-	-	-	4.97E-10	-
B. physalus	0.00006	-	5.96E-10	-	0.00006	-	-	-	0.00047	-	-	-	-	5.96E-10	-
Delphinus delphis ²	0	-	-	-	0	-	-	-	0	-	-	-	-	-	-
Feresa attenuata	0.00440	-	-	-	0.00440	-	-	-	0.00054	-	-	-	-	-	-
Globicephala macrorhynchus	0.00901	-	-	-	0.00303	-	-	-	0.00258	-	-	-	-	-	-
Grampus griseus	0.00470	-	-	-	0.00470	-	-	-	0.01021	-	-	-	-	-	-
Indopacetus pacificus	0.00310	-	-	-	0.00310	-	-	-	0.00101	-	-	-	-	-	-
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	-	-	-	0.00218	-	-	-	-	-	-
Megaptera novaeangliae	0.00477	-	4.74E-08	-	0.00250	-	-	-	0.00010	-	-	-	-	4.74E-08	-
Mesoplodon densirostris	0.00086	-	-	-	0.00134	-	-	-	0.00134	-	-	-	-	-	-
Orcinus orca	0.00006	-	-	-	0.00006	-	-	-	0.00024	-	-	-	-	-	-
Peponocephala electra	0.00200	-	-	-	0.00200	-	-	-	0.00150	-	-	-	-	-	-
Physeter macrocephalus	0.00154	-	-	-	0.00139	-	-	-	0.00128	-	-	-	-	-	-
Pseudorca crassidens	0.00078	-	-	-	0.00104	-	-	-	0.00118	-	-	-	-	-	-
Stenella attenuata	0.00605	-	-	-	0.00423	-	-	-	0.00467	-	-	-	-	-	-
S. coeruleoalba	0.00359	-	-	-	0.00513	-	-	-	0.00641	-	-	-	-	-	-
S. longirostris	0.00246	-	-	-	0.00494	-	-	-	0.00726	-	-	-	-	-	-
Steno bredanensis	0.00460	-	-	-	0.00106	-	-	-	0.00090	-	-	-	-	-	-
Tursiops truncatus	0.00301	-	-	-	0.00058	-	-	-	0.00048	-	-	-	-	-	-
Ziphius cavirostris	0.00030	-	-	-	0.00621	-	-	-	0.00621	-	-	-	-	-	-
Neomonachus schauinslandi	0.00003	9.42E-11	3.75E-10	-	0.00003*	-	-	-	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 Mammal Density Database (Hanser et al. 2013).

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 Marine Mammal Density Database due to the lack of species specific occurrence data (Hanser et al. 2013). 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. 2013).
Sonic Boom at Illeginni Islet.						
		Estimated Animals Exposed to SPLs above Behavioral Disruption Threshold				
Species		(animals per km²)	Payload impact	Sonic Boom	Total	
Green turtle ¹	Chelonia mydas	0.3846	0.0164	20.7684	20.7848	
Hawksbill Turtle ¹	Enetmochelys imbricata	0.1334	0.0057	7.2036	7.2093	

 Table 5-10

 Estimated Number of Sea Turtle Exposures to Elevated Sound Pressure Levels for payload impact and

 Sonic Boom at Illeginni Islet

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 inair splashdown SPLs for vehicle components have not been calculated, by subtracting 26 dB from inwater 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 km² (0.21 mi²; for all components) in the BOA but may exceed the behavioral disturbance threshold for these birds over 26,861 km². 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 these single-event elevated SPLs, any behavioral disturbance is expected to be limited to short-term startle responses.

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 these 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 no 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. 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). Given the presumed low densities and patchy distributions of sharks, giant manta rays, and tuna in the BOA, it is not expected that any individuals would be subject to physical injury.

Near Illeginni, 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.

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 1 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.

Sonic boom overpressures may affect, but are not likely to adversely affect, consultation cetaceans, phocids, birds, sea turtles, or fish in the BOA and if affected, are likely to only have temporary behavioral effects, not lasting adverse effects, based on the following:

- Underwater sound levels would not exceed thresholds for PTS, TTS, or behavioral disturbance for any consultation organism in the BOA;
- Only one flight test will be conducted;
- Due to the low densities and patchy distributions of consultation cetaceans, sea turtles, and sharks along the projected flight path, it is unlikely that these organisms would be affected;
- In-air sound levels will exceed the behavioral disturbance threshold for Newell's shearwaters in the BOA, however these birds have low densities and patchy distributions in the BOA;
- In the very unlikely instance that a consultation species were affected, the effects would be limited to temporary behavioral effects due to the short duration (less than 270 ms) of potential exposure to sonic boom overpressures; and
- Although loud sounds may cause consultation species to quickly react, briefly altering their normal behavior, these sounds would not cause significant or long-term effects.

Splashdown pressure levels may affect, but are not likely to adversely affect consultation cetaceans, phocids, birds, sea turtles, or fish in the BOA. If these organisms are affected, affects are likely to be only temporary behavioral effects, not lasting adverse effects, based on the following:

- High-frequency cetaceans in the BOA have the potential to be exposed to SPLs high enough to exceed the PTS threshold up to only 6.3 m (21 ft) from splashdown;
- Low-frequency cetacean and high-frequency cetaceans have the potential to be exposed to SPLs above the TTS threshold out to only 1.8 m (5.8 ft) and 12.6 m (41.3 ft) from splashdown respectively;
- Due to their low densities and patchy distributions, the chance of a cetacean being exposed to SPL high enough to induce PTS or TTS is so low as to be discountable (see analysis in section 5.1.1.3);
- The Hawaiian monk seal has the potential to be exposed to SPLs high enough to induce PTS out to only 1 m (3 ft) and TTS out to only 2 m (6.5 ft) from spent stage 1 motor splashdown;
- The Hawaiian monk seal is not likely to be found in the deep ocean waters of the BOA where components will splashdown or in the affect areas from these splashdowns and the chances of exposure are so low as to be discountable (section 5.1.1.3);
- Newell's shearwaters have the potential to be exposed to in-air SPLs high enough to induce PTS up to 398 m (1,306 ft) from splashdown and to SPLs high enough to induce behavioral response up to 89 km (55 mi);
- Underwater, Newell's shearwaters have the potential to be exposed to SPLs high enough to induce PTS out to only 2 m (6.5 ft);
- The density of Newell's shearwaters in the BOA is likely low with patchy distributions and the it is unlikely that a bird would be exposed to SPLs high enough to cause physical injury;
- Splashdown SPLs in the BOA will not exceed the mortal injury, PTS, or TTS thresholds for sea turtles;
- Sea turtles might be exposed to SPLs loud enough to exceed their behavioral threshold out to a maximum of 794 m (2,606 ft) from splashdown in the BOA, however, given the low density and patchy distribution of sea turtles in the BOA, the chance of exposure is very low (section 5.1.1.3);

- Fish species in the BOA have the potential to be exposed to SPLs high enough to exceed the injury threshold (TTS threshold) up to 40 m (131 ft) from splashdown and levels above the behavioral disruption threshold out to 2.5 km (1.4 nm);
- Due to the low densities and patch distribution of consultation fish along the projected flight path, it is unlikely that these organisms would be affected;
- Only one flight test will be conducted; and
- In the very unlikely instance that a consultation species were affected, the effects would likely be temporary behavioral effects due to the short duration (less than 1 second) of potential exposure to elevated noise from a splashdown and there is no reason to expect that there would be significant or lasting 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 stage-three drop zones (Figure 3-2). 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 may affect but are not likely to adversely 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 μ Pa 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 (\geq 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 will not be adversely affected by elevated sound levels in this area.

Sonic boom overpressures may affect, but are not likely to adversely affect, consultation cetaceans, sea turtles, or fish near Illeginni Islet and if affected, are likely to only have temporary behavioral effects, not lasting adverse effects, based on the following:

- Underwater sound levels would not exceed thresholds for PTS or TTS for any consultation organism in the BOA;
- Sound levels would exceed the behavioral disruption threshold for sea turtles in an area up to 54 km² (21 mi²) for approximately 75 ms;
- Sound levels would exceed the behavioral disruption threshold for fish in an area up to 338 km² (131 mi²) for approximately 75 ms;
- While some sea turtles and fish are likely to be subject to SPLs above the behavioral threshold, the effects would be limited to temporary behavioral effects and animals are expected to return to normal behavior within minutes of exposure;
- Only one flight test will be conducted; and
- While some animals may have a startle response lasting a couple of seconds, exposure to sonic boom SPLs are not expected to significantly disrupt natural behavior patterns.

Elevated sound pressure levels from payload impact may affect, but are not likely to adversely affect, consultation cetaceans, sea turtles, or adult fish corals or mollusk in the shallow waters near Illeginni Islet and if affected, are likely to only have temporary behavioral effects, not lasting adverse effects, based on the following:

- Underwater sound levels would not exceed thresholds for mortal injury or PTS for any consultation organism;
- Sound levels would not exceed the proposed TTS thresholds for cetaceans or sea turtles;
- Sound pressure levels may exceed the behavioral disturbance threshold for sea turtles out to 117 m (383 ft) but the densities of these organisms are expected to be low in this area and their distributions patchy;
- Sound pressures may exceed the TTS threshold for fish out to only 2 m (7 ft) from payload impact and no consultation fish are likely to be in this shoreline habitat;
- Sound pressures may exceed the behavioral disruption thresholds for scalloped hammerhead sharks, reef manta rays, or humphead wrasses present hear Illeginni Islet, however pressures would only remain above the behavioral disruption threshold out to 541 m (1,776 ft);
- Scalloped hammerhead sharks are not known to occur in the nearshore areas within 60 to 91 m (200 to 300 ft) of Illeginni Islet;
- Only one flight test will be conducted;
- Due to the low densities and patchy distributions of consultation cetaceans, sea turtles, and sharks near Illeginni Islet, it is unlikely that these organisms would be affected;
- In the very unlikely instance that a consultation species were affected, the effects would be limited to temporary behavioral effects due to the short duration of potential exposure to elevated sound pressure levels; and
- Although loud sounds may cause consultation species to quickly react, briefly altering their normal behavior, these sounds are not likely to cause significant or long-term effects and animals would be expected to return to normal behavior within minutes of disturbance.

Although densities of larval fish, coral, and mollusks have the potential to be higher in the shallow waters surrounding Illeginni Islet, elevated sound pressure levels in the area are not likely to adversely affect larval fish, corals and mollusks. Fish, corals, and mollusks are expected to respond behaviorally to acute sounds, if at all. Any modification of behavior is likely to be temporary and behavior will return to normal after a brief interval. 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.

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. 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-1 test flight, cratering and shock waves are expected to be less than those of MMIII RVs. Therefore, 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-1 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 5-1 and total approximately 61 m² (189 ft²).

Impact of Payload on Illeginni Islet. The payload impact on Illeginni Islet is the preferred alternative for the FE-1 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 the 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, we use estimates of RV cratering from MMIII test flights (USAFGSC and USASMDC/ARSTRAT 2015) as a bounding case for potential impacts of the Proposed Action.

For MMIII RVs, the ejecta field from crater formation at impact was expected to cover a semicircular area (approximately 120°) 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). 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-1 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 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 probability was not calculated for bird or fish species.

<u>Methods.</u> 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-1 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. Sea turtles were combined into a "sea turtle guild" for analyses due to the lack of species specific occurrence data (Hanser et al. 2013). 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. 2013). 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). Variables and variable calculations are summarized in Table 5-11.

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 Mammal Density Database (Hanser et al. 2013). Animal density shapefiles in the Marine Mammal Density Database were clipped for each motor

Variables Used in Direct Contact Probability Calculations.						
Variables	Definition and Units	Calculation				
А	Individual Animal Footprint (km²)	$= L_a * W_a$				
A _{buffer}	Buffered Animal Footprint (km ²)	= 0.5*I				
dc	Diameter of component (km)					
D	Species Density in the Action area (per km ²)					
Е	Number of Exposures	=N*P				
Ι	Component Impact Footprint (km ²)	$= l_{\rm C} * d_{\rm C} * N_{\rm C}$				
Р	Probability	= T/R				
lc	Length of component (km)					
La	Length of Individual Animal (km)					
Li	Length of Impact (km)	$=W_i * \left(\frac{W_a}{L_a}\right)$				
N	Number of animals in the Action Area	=D*R				
Nc	Number of each component					
f _a	Radius of Animal Footprint (km)	$= \sqrt{\frac{(L_a * W_a)}{\pi}}$				
ſ.	Radius of Impact Area (km)	$= \sqrt{\frac{(0.5 * L_i * W_i)}{\pi}}$				
R	Action Area (km ²)					
Т	Total Area of A and I overlap					
Wa	Width of Individual Animal (km)	= 20% of L_a for marine mammals				
		=112% of L_a for sea turtles				
Wi	Width of Impact (km)	$=\frac{l}{2L_i}=L_i*\left(\frac{W_a}{L_a}\right)$				

Table 5-11.

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

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 was used in direct contact analyses. For species where density shapefiles did not cover motor impact zone 3, maximum density values were interpreted from density model maps in Hanser et al. (2013).

The likelihood of an impact from FE-1 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-1 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 4 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-1 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).

<u>*Results.*</u> Based on several assumptions (discussed above), the estimated chance of a marine mammal animal exposure to direct contact from falling FE-1 components in the BOA is between 1 in 117,000 and 1 in 14,700,000 depending on individual species (Table 5-12). While we have included all possible species in these analyses, it is also important to note that many of these species are extremely unlikely to occur in the BOA or in the deep ocean waters of the Action Area (Table 4-2). The estimated chance of a Hawaiian monk seal exposure to direct contact from falling FE-1 components is 1 in 164,000,000. Even when totaled across species, the estimated chance of a marine mammal exposure is only 1 in 20,200. The model does not account for animal movement or avoidance behaviors. Since cetaceans are highly mobile, they may be able to detect and avoid approaching vehicle components to some extent. The exposure estimates were modeled based on conservative assumptions and likely results in an overestimation of probability of effect. For all cetacean species, the chances of animals being physically injured from direct contact from splashdown of vehicle components is considered discountable based on these analyses. For a land impact at Illeginni, 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-1vehicle 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 or exhibit avoidance behaviors to the approaching components.

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 may also 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 known breeding population). In a 2008 survey of USAG-KA, suitable nesting habitat (relatively open sandy beaches and seaward margins of herbaceous strand above tidal influence) for sea turtles was identified, and these areas were thoroughly surveyed on foot for nesting pits and tracks. Green 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. The most significant green turtle nesting assemblage in RMI is

	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	
	1st Stage	2nd Stage	Nose	3rd Stage	1st Stage	2nd Stage	Nose	3rd Stage	Number of Exposures
Species/ Group	Motor	Motor	Fairing	Motor	Motor	Motor	Fairing	Motor	-
Marine Mammals Balamottora acutorostrata									
Dataenopiera activitoriostrata	4.03E-08	1.86E-09	3.05E-09	7.29E-10	1.56E-06	6.31E-07	1.03E-06	5.35E-07	3.76E-06
D. voreaus	6.22E-08	3.28E-09	4.97E-09	1.41E-09	9.10E-08	4.21E-08	6.37E-08	3.45E-08	2.31E-07
B. edeni	5.78E-08	2.99E-09	4.58E-09	1.27E-09	6.30E-08	3.84E-08	5.87E-08	2.40E-08	1.84E-07
B. musculus	1.11E-07	6.81E-09	9.43E-09	3.24E-09	5.06E-08	2.73E-08	3.77E-08	3.41E-07	4.57E-07
B. physalus	8.68E-08	5.03E-09	7.20E-09	2.30E-09	4.77E-08	2.42E-08	3.46E-08	1.39E-07	2.46E-07
Delphinus delphis ²	2.28E-08	8.42E-10	1.58E-09	2.78E-10	0	0	0	0	0
Feresa attenuata	2.26E-08	8.30E-10	1.56E-09	2.73E-10	9.09E-07	2.92E-07	5.50E-07	1.88E-08	1.77E-06
Globicephala macrorhynchus	2.92E-08	1.20E-09	2.11E-09	4.32E-10	2.41E-06	2.92E-07	5.13E-07	1.43E-07	3.36E-06
Grampus griseus	4.82E-08	2.36E-09	3.73E-09	9.63E-10	2.07E-06	8.88E-07	1.40E-06	1.26E-06	5.63E-06
Indopacetus pacificus	3.78E-08	1.71E-09	2.83E-09	6.58E-10	1.07E-06	4.24E-07	7.03E-07	8.51E-08	2.28E-06
Kogia breviceps	2.46E-08	9.40E-10	1.73E-09	3.20E-10	6.55E-07	2.19E-07	4.02E-07	1.19E-07	1.40E-06
K. sima	2.28E-08	8.42E-10	1.58E-09	2.78E-10	1.49E-06	4.81E-07	9.02E-07	2.55E-07	3.13E-06
Lagenodelphis hosei	2.28E-08	8.42E-10	1.58E-09	2.78E-10	4.38E-06	1.42E-06	2.65E-06	7.78E-08	8.53E-06
Megaptera novaeangliae	6.22E-08	3.28E-09	4.97E-09	1.41E-09	2.71E-06	6.58E-07	9.95E-07	1.76E-08	4.38E-06
Mesoplodon densirostris	3.04E-08	1.27E-09	2.21E-09	4.62E-10	2.39E-07	1.36E-07	2.36E-07	7.91E-08	6.91E-07
Orcinus orca	4.03E-08	1.86E-09	3.05E-09	7.29E-10	2.21E-08	8.95E-09	1.47E-08	2.25E-08	6.82E-08
Peponocephala electra	2.28E-08	8.42E-10	1.58E-09	2.78E-10	4.17E-07	1.35E-07	2.53E-07	5.37E-08	8.59E-07
Physeter macrocephalus	5.64E-08	2.90E-09	4.46E-09	1.22E-09	7.96E-07	3.22E-07	4.96E-07	2.02E-07	1.82E-06
Pseudorca crassidens	3.04E-08	1.27E-09	2.21E-09	4.62E-10	2.16E-07	1.06E-07	1.85E-07	7.01E-08	5.77E-07
Stenella attenuata	2.13E-08	7.58E-10	1.45E-09	2.44E-10	1.18E-06	2.57E-07	4.91E-07	1.46E-07	2.07E-06
S. coeruleoalba	2.28E-08	8.42E-10	1.58E-09	2.78E-10	7.48E-07	3.46E-07	6.48E-07	2.29E-07	1.97E-06
S. longirostris	2.13E-08	7.58E-10	1.45E-09	2.44E-10	4.78E-07	3.00E-07	5.74E-07	2.27E-07	1.58E-06
Steno bredanensis	2.26E-08	8.30E-10	1.56E-09	2.73E-10	9.51E-07	7.05E-08	1.33E-07	3.16E-08	1.19E-06
Tursiops truncatus	2.58E-08	1.00E-09	1.82E-09	3.46E-10	7.09E-07	4.66E-08	8.44E-08	2.11E-08	8.61E-07
Ziphius cavirostris	3.28E-08	1.41E-09	2.41E-09	5.24E-10	9.01E-08	7.01E-07	1.20E-06	4.17E-07	2.41E-06
Neomonachus schauinslandi	2.19E-08	7.93E-10	1.50E-09	2.58E-10	6.02E-09	3.45E-11	6.55E-11	0	6.12E-09
Total Marine Mammal Exposures				2.34E-05	7.86E-06	1.37E-05	4.55E-06	4.94E-05	
Sea Turtles	Sea Turtles								
Sea Turtle Guild ²	1.70E-08	6.31E-10	1.18E-09	2.10E-10	6.70E-07	2.17E-07	1.16E-07	3.34E-07	1.41E-06

 Table 5-12.

 Probability of Direct Contact from FE-1 Vehicle Components and Estimated Number of Marine

 Mammal and Sea Turtle Exposures in the BOA.¹

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.

²Sea 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. 2013). 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. 2013).

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. 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. 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 (Eder 2011). The nests were excavated after the eggs hatched, and the numbers of hatched and unhatched eggs were estimated as follows:

- Nest excavated on 9/2/2010: approximately 56 hatched eggs and 7 unhatched eggs.
- Nest excavated on 9/25/2010: approximately 65 to 70 hatched eggs and 1 unhatched egg.
- Nest excavated on 10/28/2010: approximately 93 hatched eggs, 3 partially hatched eggs, and 1 unhatched egg.

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).

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) and sea turtle nest pits (unidentified species) 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 (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.

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) and 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. The survey occurred at depths from 5 to 10 m (16 to 33 ft; USFWS and NMFS 2006). There has been no known hawksbill nesting on Illeginni Islet.

While avoidance of a shoreline payload impact will be attempted, 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. For this reason we estimate a reasonable number of eggs or young turtles which might be affected if these events were to occur.

In their 2005 BO for MMIII activities on Illeginni Islet which had similar affect areas and stressors; the USFWS and NMFS (NMFS 2015c) estimated that the 3 nests found at Illeginni in 1996 may have contained a total of 300 eggs. Therefore, these agencies concluded that if there were test flight impacts on nests with eggs, this would be a conservative estimate of the extent of the effects.

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-1 launch, Illeginni Islet would be surveyed by pre-test personnel for sea turtles, sea turtle nesting activity, and sea turtle nests on a bi-weekly basis. 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 is 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. Even if applicable density data existed, 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 either missile parts or RVs.

Studies of coral larvae density during the peak spawning period report 0.1 to 1 planktonic larvae per m^3 (per 35.31 ft³) in waters 5 km (2.7 nm) away from 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 m² 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 m² (0.005 mi²). 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 19 coral species, 3 fish species, and 2 mollusk species have the potential to occur on the reefs and waters in the vicinity of Illeginni Islet. These forms include the relevant coral and mollusk species and adults and juveniles of the relevant fish species. 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.

<u>Methods.</u> All density estimates, estimates of the affected area, and estimates of numbers of individual organisms suffering mortality or injury were based on the best available information at the time the analysis in this BA was completed.

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 USAG-KA and, for egg and fish recruit derivations, from the literature (NMFS-PIRO 2014b). Scalloped hammerhead sharks (*Sphyrna lewini*) and reef manta rays (*Manta alfredi*) may possibly occur in the vicinity of Illeginni Islet, but due to the lack of data and rarity of observations on

these species, density estimates for these species were not derived and a project-related estimate of affected individuals for this species were not calculated. Since *Cheilinus undulatus* typically occurs in broadly distributed low numbers and has been seen near Illeginni islet, it is possible that approximately 8 adults may occur within the entire potential ocean-side affected area and 0 to 100 juveniles may occur within the entire potential affected area; however, due to a lack of supporting data, effects to eggs appear to be discountable on both sides of Illeginni at this time.

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) (NMFS-PIRO 2014a). These density values are then applied to an estimated area of habitat within the potential affected area (Table 5-13).

Estimation of Affected Area and Habitat. While coral reefs are not targeted for the FE-1 test, a payload land strike on the shoreline could result in ejecta/debris fall and shock wave effects, which will 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 RV 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, we estimate that the 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, 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. Since the debris fall affect area is larger than the shock wave affect area, we calculated the effects of the Action based on the debris fall/ejecta area. Although the exact shape of the affected area is impossible to pre-determine, the seaward portion of such an area is conceptually illustrated as a rough semi-circle on the lagoon and ocean sides of Illeginni with a radius of 91 m (Figure 5-1).

The aerial extent of potential debris fall effects on the lagoon and ocean sides of Illeginni were calculated to be $\frac{1}{2} (\pi r^2)$ or 13,008 m² (0.005 mi²). Each of these areas (Figure 5-1) would be subject to potential debris fall based on debris fall distance analyses for MMIII RVs (USAFGSC and USASMDC/ARSTRAT 2015). Based on best professional judgment, approximately 10,406 m² (0.004 mi²; 80%) of the lagoon-side affected area (Figure 5-1) is considered to be potentially viable habitat for consultation fish, coral and mollusks. Similarly, approximately 9,756 m² (0.004 mi²; 75%) of the ocean-side affected area (Figure 5-1) is considered to be potentially viable habitat for consultation fish, coral and mollusks. Similarly, approximately 9,756 m² (0.004 mi²; 75%) of the ocean-side affected area (Figure 5-1) is considered to be potentially viable habitat for consultation fish, coral and mollusks. NMFS-PIRO, Pers. Comm., 2014).

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



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

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 should be regarded as an overestimate and those of maximum effect.

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.

<u>Results.</u> 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. 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 8 adults and 0 juveniles.

Based on conservative density estimates 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

Lotinated i tank									
		Estimated Colonies		Lagoon-side Debris		Ocean Side Debris			
		or Individuals ⁽²⁾		Fall Area		Fall Area			
				# of			# of		
				Affected	Colonies	Affected	Colonies		
	Applicable	Mean	99% UCL	Habitat	or	Habitat	or		
Species	Habitat	(per m ²)	(per m ²)	(m ²)	Individ.	(m ²)	Individ.		
Corals									
Acanthastrea brevis	Flat, Crest & Slope	0.02	0.08	5,203	416	4,878	390		
Acropora aculeus	Flat, Crest & Slope	0.02	0.08	5,203	416	4,878	390		
Acropora aspera ³	Flat	3.1	5.08	40	203	40	203		
Acropora dendrum	Flat, Crest & Slope	0.02	0.08	5,203	416	4,878	390		
Acropora listeri	Flat, Crest & Slope	0.02	0.08	5,203	416	4,878	390		
Acropora microclados	Flat, Crest & Slope	0.02	0.08	5,203	416	4,878	390		
Acropora polystoma	Flat, Crest & Slope	0.02	0.08	5,203	416	4,878	390		
Alveopora verrilliana	Flat, Crest & Slope	0.04	0.16	5,203	832	4,878	780		
Cyphastrea agassizi	Flat, Crest & Slope	0.02	0.08	5,203	416	4,878	390		
Heliopora coerulea	Flat, Crest & Slope	0.16	0.53	5,203	2,758	4,878	2,585		
Leptoseris incrustans	Flat, Crest & Slope	0.02	0.08	5,203	416	4,878	390		
Montipora caliculata	Flat & Slope	0.06	0.14	5,203	728	4,878	683		
Pavona venosa	Flat, Crest & Slope	0.02	0.08	5,203	416	4,878	390		
Turbinaria reniformis	Flat, Crest & Slope	0.04	0.16	5,203	832	4,878	781		
Turbinaria stellulata	Flat, Crest & Slope	0.04	0.16	5,203	832	4,878	781		
Coral Subtotal					9,929		9,323		
Mollusks									
Trochus niloticus	Flat, Crest & Slope	0.05	0.09	5,203	468	4,878	439		
Mollusk Subtotal		0.09		468		439			

 Table 5-13.

 Estimated Numbers of Consultation Coral Colonies and Individual Mollusks in Affected Habitats.¹

¹The species in this table exclude those found only on reef slopes or have not been observed on reef flats at Illeginni. This latter group of species has been eliminated from effect calculations since they are not expected to occur in the FE-1project affected habitats.

² The coral and mollusk densities are the 99% UCL of mean estimated densities provided by NMFS-PIRO (2014a).

³ Since *Acropora aspera* is a species that typically occurs in aggregations, it is estimated that the total area occupied within either the lagoon-side or ocean-side affected habitat would not exceed 40 m².

the lagoon side, estimates of the maximum numbers of coral colonies and individual mollusks are 9,097 and 468, respectively, in habitat affected by debris fall. On the ocean side, estimates of the maximum numbers of coral colonies and individual mollusks are 8,543 and 468, respectively.

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 (NMFS-PIRO 2014a and 2014b). 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. Moreover, this area is considered extremely small compared to sum of comparable reef areas under US control per the current military use agreement with the RMI, and miniscule in comparison with comparable reef areas within the entire atoll. A summary of recorded distributions of these consultation species, based on observations made during the 2012 USAG-KA inventory and project surveys over the previous five years, is shown in Table 4-7. A total of 95 sites were surveyed for protected corals since 2008. Of the 15 coral species that have the potential to be affected as adults, all were observed at multiple islets and 80% were observed at more than 5 islets. Most of the species appeared to be geographically widespread with observed occurrences of 4 species, *Acropora microclados, Heliopora coerulea, Pavona venosa*, and *Montipora caliculata*, exceedingly common. Although the scalloped hammerhead shark is uncommon, the humphead wrasse is common in distribution within USAG-KA. A total of 103 sites were surveyed for protected fish since 2008. *Cheilinus undulatus* has been seen at 10 of the11 islets. All of the fish, coral and mollusk species for which takes have been requested are known 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 very common sources within the 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 1 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-1 vehicle components in the BOA may affect, but are not likely to adversely affect, cetaceans, the Hawaiian monk seal, Newell's shearwaters, sea turtles, the giant manta ray, the Pacific bluefin tuna, or 2 species of sharks. As analyzed above in section 5.1.2.2, the chance of an individual cetacean, monk seal, 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 fish in the BOA, their densities are likely to be very low and patchy as well. Cetaceans, phocids, birds, sea turtles, and sharks are highly mobile organisms which may be able to detect and avoid falling vehicle components. In addition, only one FE-1 test will be conducted and is scheduled to take place in within a year after the signing of the FONSI, if approved.

Direct contact from splashdown of rocket components may affect individual larval fish, corals, and mollusks but 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.

Vicinity of Illeginni Islet. At Illeginni Islet, the payload is planned to impact over land. Impacts in most areas of the Illeginni impact zone would not affect marine environments. There is a chance that the payload would impact on the Illeginni 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 is analyzed in this BA to evaluate the maximum effects on biological resources.

Most cetacean species (\geq 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 affects from direct contact with payload fragments or

ejecta are expected to occur within 91m (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 shoreline.

Reef 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 reef manta ray is known to occur near Kwajalein Islet in Kwajalein Atoll, this species has not been observed near Illeginni Islet in biennial inventories. The chance of a reef 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 adversely affected by payload impact on Illeginni Islet. While 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, it is possible that a land strike could adversely affect sea turtle nesting habitat on Illeginni. Should payload debris or ejecta impact sea turtle nesting habitat, a nest could be destroyed or a portion of nesting habitat could be damaged or lost (see discussion in section 5.1.2.2 above). While mitigation measures will be taken to detect sea turtles or sea turtle nests in the Action Area, we conclude that a payload impact on land at Illeginni Islet may affect and is likely to adversely affect sea turtle nesting.

Direct contact from payload fragments or ejecta may affect and is likely to adversely affect the humphead wrasse, 15 species of consultation corals, and 1 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 very high estimates and 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; 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.

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. 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. Post-test recovery efforts will also result in increased vessel traffic to the payload impact site. There will be approximately 4 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 30.5 m (100 ft) deep. Post-test

vessel traffic will likely include 4 vessel round-trips to and from Illeginni Islet and LCU retrieving raftborne sensors. Vessel traffic to and from Illeginni Islet will be increased for a period of 10 weeks.

The Action will also 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 Mobile Aerial Target Support System (MATSS) out of PMRF, the Kwajalein Mobile Range Safety System (KMRSS) on board the US Motor Vessel (USMV) Worthy, and the Raytheon Portable Instrumented Range Augmentation Telemetry Equipment System (PIRATES). All of these sensors are existing programs and would be scheduled for use based on availability.

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 1 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 may affect, but is not likely to adversely affect, cetaceans, the Hawaiian monk seal, Newell's shearwaters, sea turtles, the giant manta ray, the Pacific bluefin tuna, or 2 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 may affect individual larval fish, corals, and mollusks but the effects are considered insignificant or discountable. The abundance of larval fish, corals, and mollusks in the BOA is likely to be extremely low. The Proposed Action may injure or kill a small but undeterminable number of fish, coral, and mollusk larvae; however, 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.

Vicinity of Illeginni Islet. Fourteen consultation species of cetaceans, Hawaiian monk seals, Newell's shearwaters, 3 species of sea turtle, and 4 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 or a vessel contacting reef habitats, although this is unlikely, vessel operators will be made aware of sensitive reef habitats in order to avoid these areas; and
- Vessel operators will watch for and avoid cetaceans and sea turtles by adjusting their speed (see Section 3.4, Mitigation Measures).

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. Splashdown 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-1 flight or spent motor jettison will fall into the BOA when first-, second-, and third-stage launch vehicle motors and nose fairing are released (Table 3-1). The launch vehicle includes rocket motors, solid 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 cetacean or sea turtle 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 will likely not be in contact with these materials. Any chemicals 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 four lithium ion batteries each weighing between 3 and 50 pounds 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 1,000 lbs 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 other alloys.

With the payload impact on Illeginni, debris including hazardous materials would fall on Illeginni 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 off all visible debris including during crater backfill. Searches for debris would be attempted out to water depths of 15 to 30.5 m (50 to 100 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 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 1,000 lbs 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 unknowable 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 alloving 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 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 are largely unknown, the impact area is largely a disturbed area where there would not likely be significant environmental effects. As a mitigation measure, the US Navy and USASMDC have begun a bench study to measure the dissolution and migration of the tungsten alloy used in this study in Illeginni Islet soils. While the results of the bench study will likely not be available before the Action takes place, this study will inform future biological resource analyses of the effects of tungsten in soils such as those found at Illeginni Islet.

Up to four small radars powered by car batteries are considered expendable and will 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 diluted 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. 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, 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 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.
- 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 1 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 may affect, but is not likely to adversely affect, consultation organisms because of the following:

- 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 cetaceans and sea turtles 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, 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 (\geq 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 91m (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 91m (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 and are likely to adversely affect nesting sea turtles, sea turtle nests, and/or sea turtle nesting habitat. As discussed in section 5.1.2.2 (Estimation of Direct Contact Effects), debris and ejecta from payload impact has the potential to impact sea turtle nesting habitat. 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. While post-test cleanup will be conducted, there is a chance that fragments or residual chemicals may remain in sea turtle nesting habitat. For these reasons we find the effects of hazardous chemicals from the Action to be more than discountable and potentially harmful.

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 in both terrestrial an ocean areas. Post-flight cleanup will involve recovery of all debris possible and will include personnel and equipment in both terrestrial and ocean 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 above in section 5.1.3. Elevated levels of human activity are expected for approximately 10 weeks at Illeginni Islet. During these this period, approximately 8 vessel round-trips are likely. Helicopters will also be used to transport equipment and personnel to Illeginni with 2 to 4 daily trips. The Action is expected to involve as many as 2 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 coral that had been ejected around the wall of the crater. Use of heavy equipment, if necessary, will be coordinated with USFWS/NMFS in order to minimize impacts to sensitive resources (see section 3.4, Mitigation and 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 due to the nature of the operations.

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 may be moved out of the way, it is unlikely that a top shell snail would be killed due to the strong and protective nature of the snail's thick shell. Sea turtles, humphead wrasses, and reef 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.

All land-based post-flight activities have the potential to increase turbidity, especially for 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 affects are expected to be insignificant.

In shallow waters near Illeginni, corals, mollusks, and the humphead wrasse have the potential to be disturbed by shallow water debris recovery and/or backfill operations. 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 very small pieces of RV debris that they would be looking for. 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 greater than or outside of 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 1 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 may affect but is not likely to adversely affect 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 these natural behavioral patterns would not be significantly altered.

Vicinity of Illeginni Islet. Most cetacean species (\geq 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 in the water, scalloped hammerhead sharks, reef 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; and
- 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.

Disturbance from human activity and equipment operation may affect and is likely to adversely affect nesting sea turtles, sea turtle nests, and/or sea turtle nesting habitat. As discussed in section 5.1.2.2 (Estimation of Direct Contact Effects), debris and ejecta from payload impact has the potential to impact sea turtle nesting habitat. While a shoreline impact may be avoided, debris and ejecta has the potential to extend out 91 m (300 ft) from payload impact, which may affect sea turtle nesting habitat. Post-flight cleanup operations include recovery/cleanup of visible payload debris and backfilling of any payload created crater. During post-flight operations, heavy equipment may be used to recover land-based debris (including hazardous materials), backfill craters, and restore potential sea turtle nesting habitat. It is possible that during these operations, heavy equipment may severely damage or destroy turtle eggs and may physically change the habitat, making it unsuitable for future successful nesting. While test operations may be scheduled outside of the sea turtle breeding season, there is a chance that these activities may disturb turtles or affect sea turtle nests or nesting habitat. Several mitigation measures will be employed minimize potential effects including pre-flight monitoring for sea turtle nests, reporting of sea turtle observations near Illeginni, and allowing USFWS of NMFS biologists to provide guidance should debris be found in sea turtle nesting habitat. For these reasons we find the effects of disturbance from Action-related human activities or equipment operation to be more than discountable and potentially harmful.

Disturbance from human activity and equipment operation may affect and is likely to adversely affect consultation corals (14 species), top snails, 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), if there are effects, these effects are expected to be adverse because:

• Recovery and cleanup activities 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.

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-1 flight test program and the activities and considerations in Table 6-1 below.

Future Act	tions a	nd Other Environmental Considerations I	dentified 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			

Table 6-1.

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-1 test flight on consultation species, and discusses the cumulative effects of rocket launches (including FE-1) 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 has 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 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 percent 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, Trochus (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 8 member-nations (MIMRA 2017). Since 2010, the PNA has resulted in regional management and conservation measures which relate to the oceanic tuna fishery (MIMRA 2017). According to MIMRA, less than two percent 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 is 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 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). While 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 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 1/3 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/RTS employees between islets within Kwajalein Atoll. Larger supply container ships transport materials and supplies to USAG-KA about every 2 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.

6.1.4 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 affects 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 CO₂ 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 CO₂ and other greenhouse gas concentrations have increased, air temperatures have increased and so have ocean temperatures (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 changes 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 have 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 cetaceans 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 U.S. 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-1 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-1 acoustic or direct contact effect is so low as to be discountable. Therefore, it is unlikely that FE-1 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 have 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 percent 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-1 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-1 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 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 percent 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-1 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-1 acoustic or direct contact effect is so low as to be discountable; therefore, it is unlikely that FE-1 activities would contribute to or increase cumulative impacts on sea turtles in marine habitats.

It is possible that FE-1 activities may damage green or hawksbill turtle nests or nesting habitat at Illeginni Islet. Sea turtle nests or 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 and nest pits were recorded in 1996; however Illeginni Islet is not likely a significant nesting site. While surveys for sea turtle haul outs or nesting activity will be conducted pre-test, the effects from FE-1 activities on sea turtle nests or nesting habitat are more than discountable and potentially harmful. Green turtles nest on several atolls, but USAG-KA is not a significant nesting area. Based on available information, NMFS and USFWS (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).

Although the proposed FE-1 activities have the potential to adversely impact green or hawksbill turtle nests or nesting habitat, any realized effect would be very small in relation to turtle nesting populations at Kwajalein Atoll or the central west Pacific. Therefore, the contribution of FE-1 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 percent 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 percent 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 have 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-1 activities. The Proposed Action is a single event taking place over a very short time period and UES consultation fish species have low densities in the Action Area. Therefore, it is unlikely that FE-1 activities would contribute to or increase cumulative impacts on fish.

A small but inestimable number of larval fish may be affected by FE-1 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-1 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-1 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, is exposed to the effects of a variety of activities including past and ongoing missile tests, UXO 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 USAG-KA

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 *Trochus*, aquarium fish, and corals (FAO 2009). Exports from the coastal commercial fisheries are primarily aquarium fish and coral for US markets and *Trochus* for button factories in Asia and Europe (FAO 2009). The aquarium fishery operating at Majuro and Enewetak Atolls supports most of the *Trochus* 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 *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 are effects 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 above 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-1 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-1 activities would contribute to or increase cumulative impacts on larval coral or mollusks.

For adults, 5 species of consultation coral (*Acropora speciosa, A. tenella, A. vaughani,* and *Leptoseris incrustans*) and 1 mollusk species (*Pinctada margaritifera*) are not likely to be adversely affected by FE-1 activities in the Action Area. Adults of these species do not occur in the BOA, and those that may occur at Illeginni Islet are not known to occur in the shallow waters potentially affected by FE-1

activities. Therefore, it is unlikely that FE-1 activities would contribute to or increase cumulative impacts for these species.

Fourteen other species of consultation coral (section 5.1.2) and *Trochus niloticus* may be adversely affected by direct contact from payload debris or impact ejecta or by disturbance from human activity or equipment operation. 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 9,097 coral colonies and 468 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-1 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 (Al₂O₃; 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 μ m 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 criteria 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 emission 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 and subsequently warming the atmosphere. Toohey (n.d.) states that "it is estimated that black carbon emitted by rockets is over 1 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 miniscule 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-1 launch will produce emissions which will contribute to climate change and ozone depletion, the single FE-1 flight test is unlikely to significantly contribute to or increase the cumulative effects of climate change or ozone depletion.
7.0 Conclusions

7.0 CONCLUSIONS

Based on analyses of all of the potential stressors in the Action Area, we have determined that the Proposed Action "may affect but is not likely to adversely affect" all 24 cetacean species, Hawaiian monk seals, Newell's shearwaters, sea turtles in the water, 3 species of sharks, 2 manta ray species, Pacific bluefin tuna, 5 species of coral, Black-lipped pearl oysters, and larval fish, coral, and mollusks (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 and 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 certain parts of the Action Area, the Proposed Action "may affect and is likely to adversely affect" sea turtle nesting, the humphead wrasse, 14 coral species, and top snails (Table 7-1). Green turtle and hawksbill turtle nesting is likely to be adversely affected at Illeginni Islet by direct contact, exposure to hazardous chemicals, and human disturbance on Illeginni Islet. While unlikely, past analyses of impacts to sea turtle nesting at Illeginni Islet have estimated that a maximum of 3 sea turtle nests might be affected with a maximum total of 300 sea turtle eggs affected (detailed in section 5.1.2). Based on the best available information about species distributions and the effects of the stressors, the humphead wrasse, 14 species of coral and top shell snails may be adversely affected by direct contact from payload debris and ejecta or by disturbance from human activity or equipment operation. All 14 of these species coral species are known to occur on at least 2 other islets in Kwajalein Atoll as well as in the mid-atoll corridor (Table 4-7). The top shell snail is found near all surveyed islets in Kwajalein Atoll and in the mid-atoll corridor (Table 4-8). Considering the worst-case scenario of a shoreline payload impact, analyses provide evidence that a maximum of 8 adult or 100 juvenile humphead wrasse, 9,097 coral colonies, and 468 individual mollusks might be affected by FE-1 activities (detailed in section 5.1.2).

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 know to be present in effect area, ○=may affect but not likely to adversely affect, ●=likely to adversely affect).

				BOA	L		V	icinit	y of I Islet	llegir	nni
Scientific Name	Common Name	Elevated Sound	Direct Contact	Vessel Strike	Hazard. Chem.	Human Disturb.	Elevated	Direct	Vessel Strike	Hazard. Chem.	Human Disturb.
Cetaceans											
Balaenoptera acutorostrata	Minke whale	0	0	0	0	0	0	-	0	-	0
B. borealis	Sei whale	0	0	0	0	0	-	-	-	-	-
B. edeni	Bryde's whale	0	0	0	0	0	0	-	0	-	0
B. musculus	Blue whale	0	0	0	0	0	-	-	-	-	-
B. physalus	Fin whale	0	0	0	0	0	-	-	-	-	-
Delphinus delphis	Short-beaked common dolphin	-	-	-	-	-	0	-	0	-	0
Feresa attenuata	Pygmy killer whale	0	0	0	0	0	-	-	-	-	-
Globicephala macrorhynchus	Short-finned pilot whale	0	0	0	0	0	0	-	0	-	0
Grampus griseus	Risso's dolphin	0	0	0	0	0	-	-	-	-	-
Indopacetus pacificus	Longman's beaked whale	0	0	0	0	0	-	-	-	-	-
Kogia breviceps	Pygmy sperm whale	0	0	0	0	0	-	-	-	-	-
K. sima	Dwarf sperm whale	0	0	0	0	0	-	-	-	-	-
Lagenodelphis hosei	Fraser's dolphin	0	0	0	0	0	-	-	-	-	-
Megaptera novaeangliae	Humpback whale	0	0	0	0	0	-	-	-	-	-
Mesoplodon densirostris	Blainville's beaked whale	0	0	0	0	0	-	-	-	-	-
Orcinus orca	Killer whale	0	0	0	0	0	0	-	0	-	0
Peponocephala electra	Melon-headed whale	0	0	0	0	0	0	-	0	-	0
Physeter macrocephalus	Sperm whale	0	0	0	0	0	0	-	0	-	0
Pseudorca crassidens	False killer whale	0	0	0	0	0	-	-	-	-	-
Stenella attenuata	Pantropical spotted dolphin	0	0	0	0	0	0	-	0	-	0
S. coeruleoalba	Striped dolphin	0	0	0	0	0	0	-	0	-	0
S. longirostris	Spinner dolphin	0	0	0	0	0	0	-	0	-	0
Steno bredanensis	Rough-toothed dolphin	0	0	0	0	0	-	-	-	-	-
Tursiops truncatus	Bottlenose dolphin	0	0	0	0	0	0	-	0	-	0
Ziphius cavirostris	Cuvier's beaked whale	0	0	0	0	0	-	-	-	-	
Phocids											
Neomonachus schauinslandi	Hawaiian monk seal	0	0	0	0	0	-	-	-	-	-
Birds											
Puffinus auricularis newelli	Newell's shearwater	0	0	0	0	0	-	-	-	-	-
Sea Turtles											
Caretta caretta	Loggerhead turtle	0	0	0	0	0	-	-	-	-	-
Chelonia mydas	Green turtle	0	0	0	0	0	0	•	0	٠	•

7.0 Conclusions

				BOA	L		Vi	icinit	y of I Islet	llegir	nni
	Common Name	Elevated Sound	Direct Contact	Vessel Strike	Hazard. Chem.	Human Disturb.	Elevated Sound	Direct Contact	Vessel Strike	Hazard. Chem.	Human Disturb.
Dermochelus coriacea	Leatherback turtle	0	0	0	0	0			,		
Eretmochelys torracca	Hawksbill turtle	0	0	0	0	0	-	-	-	-	-
Letidochelys olivacea	Olive ridley turtle	0	0	0	0	0	0	•	0	•	•
Explantify our atta	Onve hatey turne	0	0	0	0	0	-	-	-	-	-
Fish (non-larval)											
Alopias superciliosus	Bigeye thresher shark	0	0	0	0	0	-	-	-	-	-
Carcharhinus longimanus	Oceanic whitetip shark	0	0	0	0	0	-	-	-	-	-
Cheilinus undulatus	Humphead wrasse	-	-	-	-	-	0	•	0	0	•
Manta alfredi	Reef manta ray	-	-	-	-	-	0	0	0	0	0
M. birostris	Oceanic giant manta ray	0	0	0	0	0	-	-	-	-	-
Sphyrna lewini	Scalloped hammerhead	-	-	-	-	-	0	-	0	-	0
Thunnus orientalis	Pacific bluefin tuna	0	0	0	0	0	-	-	-	-	-
Corals (non-larval)			•							•	
Acanthastrea brevis		-	-	-	-	-	0	•	0	0	•
Acropora aculeus		-	-	-	-	-	0	•	0	0	•
A. aspera		-	-	-	-	-	0	٠	0	0	•
A. dendrum		-	-	-	-	-	0	٠	0	0	•
A. listeri		-	-	-	-	-	0	•	0	0	•
A. microclados		-	-	-	-	-	0	•	0	0	•
A. polystoma		-	-	-	-	-	0	•	0	0	•
A. speciosa		-	-	-	-	-	0	0	0	0	0
A. tenella		-	-	-	-	-	0	0	0	0	0
A. vaughani		-	-	-	-	-	0	0	0	0	0
Alveopora verilliana		-	-	-	-	-	0	•	0	0	•
Cyphastrea agassizi		-	-	-	-	-	0	•	0	0	•
Heliopora coerulea		-	-	-	-	-	0	•	0	0	•
Leptoseris incrustans		-	-	-	-	-	0	0	0	0	0
Montipora caliculata		-	-	-	-	-	0	•	0	0	•
Pavona cactus		-	-	-	-	-	0	0	0	0	0
P. venosa		-	-	-	-	-	0	•	0	0	•
Turbinaria reniformis		-	-	-	-	-	0	٠	0	0	•
T. stellulata		-	-	-	-	-	0	•	0	0	•
Mollusks (non-larval)											
Pinctada margaritifera	Black-lipped pearl oyster	-	-	-	-	-	0	0	0	0	0
Trochus niloticus ⁵	Top shell snail	-	-	-	-	-	0	•	0	0	•
Larval Fish, Coral, and M	Iollusks	0	0	0	0	0	0	0	0	0	0

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APPENDIX A ANALYSIS OF FE-1 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 One (FE-1) flight test will consist of a launch point to target test of a developmental payload. During flight, the payload is boosted by three stages to exoatmospheric altitudes. Following boost, the payload is deployed, and flies to the impact area. During flight, an 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 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 high-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 (overpressure) followed by a decrease to an under pressure 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 observers 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 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-1 stages is on the order of $4x10^9$ 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-1 flight test acoustic intensities as well as affected areas associated with both the sonic boom throughout the payload's trajectory and stage impacts.

A2 Methodology

One of the main objectives of this analysis was to provide a means of predicting the total affected seasurface 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), Section A3.1 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 μ Pa, the convention for sound intensity in water. Note that typically, sound intensity in air is reported as dB relative to a reference pressure of $2x10^{-5}$ Pa. 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-1 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 "affected 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 propagate the stage during its reentry 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.
- Acoustic intensity (dB) values were calculated based on empirical equations (Section A3.2, eqn. 3.1) 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 μ Pa (dB re 1 μ Pa).
- 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, $C_D = 1$ and $C_D = 3$. Note that higher C_D 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 C_D 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 Section A3.2 below 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 affected 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:

Sonic Boo	Table om Intensity in Water av	A-1 t 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 the 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) Affected Area (km²) as a function of acoustic level (dB re 1 μ Pa). Table A-2 contains the actual numerical values from Figure A-2.



Figure A-2. Plot of Area Affected vs. sound intensity for the Sonic Boom and Stage Impacts.

dB	Sonic	1 st Stage		2 nd 5	2 nd Stage Nose Fairing 3 rd			3rd S	tage
re 1 µPa	Boom	Cd = 1	Cd = 3	Cd = 1	Cd = 3	Cd = 1	Cd = 3	Cd = 1	Cd = 3
100	545,519	1,850,567	562,071	102,192	33,376	13,552	4,486	37,228	12,254
110	507,705	185,057	56,207	10,219	3,338	1,355	449	3,723	1,225
120	416,177	18,506	5,621	1,022	334	136	45	372	123
130	84,566	1,851	562	102	33	14	4	37	12
140	1,552.2	185.1	56.2	10	3.3	1.4	0.4	3.7	1.2
150	304	19	6	1.0	0.3	0.1	0.004	0.4	0.1
160	52	1.9	0.6	0.1	0.03	0.01	0.004	0.04	0.01
170	3.4	0.2	0.1	0.01	0.003	0.001	0.0004	0.004	0.001
180	0	0.02	0.01	0.001	0.0003	0.0001	0.00004	0.0004	0.0001
190	0	0.002	0.001	0.0001	0.00003	0.00001	4 x 10 ⁻⁶	0.00004	0.00001
200	0	0.0002	0.0001	0.00001	3 x 10-6	1 x 10-6	4 x 10-7	4 x 10-6	1 x 10-6
210	0	0.00002	0.00001	1 x 10-6	3 x 10-7	1 x 10 ⁻⁷	4 x 10 ⁻⁸	4 x 10 ⁻⁷	1 x 10 ⁻⁷
220	0	2 x 10-6	1 x 10-6	1 x 10-7	3 x 10 ⁻⁸	1 x 10 ⁻⁸	4 x 10-9	4 x 10 ⁻⁸	1 x 10 ⁻⁸

Table A-2Tabular values of Affected Area (km²).

Values in sound intensity in Figure A-2 and Table A-2 show that the sonic boom has a much larger affected area at levels less than ~175 dB re 1 μ Pa 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 μ Pa, the stage impacts dominate with affected areas of 1 km² or less. Also note the difference in the C_D = 1 vs. C_D = 3 stage impact intensity where the values associated with C_D = 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-1 flight trajectory, the duration of the sonic boom is on average:

- \sim 268 ms for intensities less than 140 dB re 1 μ Pa
- \sim 75 ms for intensities greater than 140 dB re 1 μ Pa

Unfortunately, due to the complexity of the stage impact dynamics, estimates of the duration of the acoustical disturbance 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.

A3.1 Sonic Boom Calculations

Symbols used in sonic boom calculations are presented in Table A-4. 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:

$$\Delta p_{max} = K_p K_R \sqrt{p_v p_g} (M^2 - 1)^{1/8} h_e^{-3/4} l^{3/4} K_S \text{ and } I = 20 \log_{10} \left(\frac{\Delta p_{max}}{p_{Ref}} \right)$$

To evaluate this, we start by defining the vehicles effective Mach number:

$$M_e = \sqrt{1 + \frac{[A(1 - B \tan \gamma)]^2}{[A(\tan \gamma + B]^2 + (C \cdot D)^2]}}$$

where

$$A = \frac{1}{\cos \gamma \sqrt{M^2 - 1}}, \quad B = \frac{1}{\cos \theta \sqrt{M^2 - 1}}, \quad C = \frac{\tan \theta}{\sqrt{M^2 - 1}} \quad \text{and} \quad D = \tan^2 \gamma + 1$$

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.

$$K_{d} = K_{d,c} + \left(K_{d,\infty} - K_{d,c}\right) \left(\frac{M_{e} - M_{c}}{M_{e} - 1}\right)^{n_{d}}$$
$$K_{p} = K_{p,\infty} \left(\frac{M_{e} - 1}{M_{e} - M_{c}}\right)^{n_{p}}$$
$$K_{t} = K_{t,\infty} \left(\frac{M}{M - 1}\right)^{n_{t}}$$



Given the above, we can now calculate the following:

$$d = K_d \left(\frac{h_v - h_g}{\sqrt{M_e^2 - 1}}\right) \text{ and } \tan \phi = \frac{D \cdot \tan \theta \cos \gamma}{\tan \gamma + B}$$
$$d_x = d \cos \phi \text{ and } d_y = d \sin \phi$$
$$h_e = \sqrt{d_y^2 + \left((h_v - h_g)\cos \gamma + d_x \sin \gamma\right)^2}$$

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

$$B(x) = K_L \int_0^x b(x) dx$$

FE-1 BIOLOGICAL ASSESSMENT

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

 $x = l_e$ such that $A_e(x = l_e)$ is a maximum defined to be $A_{e,max}$

We then define

$$A_{e,1} = A_e(\frac{1}{2}l_e).$$

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.



Lastly, in addition to Δp , the duration of the shockwave may also be calculated via the following:

$$\Delta t = K_t \frac{3.42}{a_v} \frac{M}{(M^2 - 1)^{3/8}} h_e^{1/4} l^{3/4} K_s$$

Table A-3List 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, le, m ²
$a_{\rm v}$	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
dy	component of d in direction perpendicular to aircraft ground track (i.e. in lateral direction), km
d _{y, c}	value of dy at lateral limit or cutoff of sonic-boom ground footprint, km
h	altitude of aircraft above ground, h _y - h _g , km

Symbol	Definition
he	effective altitude, km
hg	altitude of ground above sea level, km
$h_{\rm v}$	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,∞}	pressure amplification factor for an infinite Mach number
K _R	reflection factor, assumed to be 2.0
Ks	aircraft shape factor
Kt	signature duration factor
K _{t,∞}	signature duration factor for an infinite Mach number
l	aircraft characteristic length, normally the fuselage length, m
le	effective length of aircraft used in determination of aircraft shape factor, m
Μ	aircraft Mach number
M_{c}	aircraft cutoff Mach number below which sonic boom will not reach ground
Me	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
nt	exponent of Mach number parameter in atmospheric signature duration factor curve fit
р	atmospheric pressure, Pa
Δp	incremental pressure due to sonic boom, Pa

Table A-3List of Symbols Used in Sonic Boom Calculations

A3.2 Stage Impact Calculations

The acoustic impact of FE-1 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 (OEA) 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 extension 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.

Maximum contact areas for the stages are as follows:

1st stage: 81.12 ft² 2nd stage: 33.38 ft² 3rd stage: 19.5 ft² Nose fairing: 55.14 ft² 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 $R^2 = 1$:

$$dB \ re \ 1\mu Pa^2 - s \cong 4.3512 * \ln\left(\frac{E_{AC}}{10^4}\right) + 204.26$$
 A.1

where E_{AC} is the radiated acoustic energy in Joules and the maximum $1/3^{rd}$ 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.

Pressure values for source dB for ocean impact events in the BOA.					
Impact Event	Source dB Va	llue (1 µPa ² -s)			
Impact Event –	$C_D = 1$	$C_D = 3$			
1 st Stage	217.70	212.53			
2 nd Stage	205.12	200.26			
Nose fairing	196.35	191.55			
3 rd Stage	200.74	195.91			

Table A-4

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:

$$ZOI = r_{shock} * 10 \left(\frac{\frac{dB_{source} - 20 \cdot \log\left(\frac{r_{shock}}{r_0}\right) - dB_{thresh}}{20}}{20} \right)$$
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:

$$KE_{imp} = \frac{1}{2}mv_{imp}^{2} = \frac{1}{2} * 1890.35kg * \left(152.39\frac{m}{s}\right)^{2} = 2.195 * 10^{7} Joules$$
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.

$$E_{AC} = 0.01 * KE_{imp} = 2.195 * 10^5 Joules$$
 A.4

Using the empirical relationship to convert acoustic energy to source dB values results in the following:

$$dB_{source} = 4.3512 * \ln\left(\frac{2.195E5}{10^4}\right) + 204.26$$
 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:

$$ZOI = 32.51 * 10^{\left(\frac{217.7 - 20 \cdot \log(32.51) - 182}{20}\right)} \cong 60.95m$$

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.