Endangered Species Act – Section 7 Consultation

Action Agency:	Department of the Air Force, U.S. Air Force (USAF) Nuclear Weapons Center, U.S. Army Space and Missile Defense Command (USASMDC) – Huntsville AL
Activity:	Ground Based Strategic Defense (GBSD) Test Program Activities
Consulting Agency:	National Marine Fisheries Service, Pacific Islands Region, Protected Resources Division
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Approved By:	Michael D. Tosatto Regional Administrator, Pacific Islands Region
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Table of Contents

List of Figures

List of Tables

ACRONYMS

BA	Biological Assessment
BMP	Best Management Practice(s)
BO	Biological Opinion
BOA	Broad Ocean Area
CFR	Code of Federal Regulations
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
cm	Centimeters
CO_2	Carbon Dioxide
dB	Decibel
DEP	Document of Environmental Protection
DoD	Department of Defense
DPS	Distinct Population Segment
DQA	Data Quality Act
EIS	Environmental Impact Statement
ESA	Endangered Species Act
FE-1	Flight Experiment-1
FE-2	Flight Experiment-2
ft	Feet
FR	Federal Register
FWS	US Fish and Wildlife Service
FY	Fiscal Year
GBSD	Ground Based Strategic Deterrent Weapon System
HAFB	Hill Air Force Base
Hz	Hertz
ICBM	Intercontinental Ballistic Missile
in	Inch(es)
kg	Kilogram(s)
km	Kilometer(s)
km^2	Square Kilometer(s)
LAA	Likely to Adversely Affect
LLNL	Lawrence Livermore National Laboratory
m	Meter(s)
MAC	Mid-Atoll Corridor
mi^2	Square Mile(s)
MMIII	Minuteman III Weapon System
MMPA	Marine Mammal Protection Act
NEPA	National Environmental Policy Act
NLAA	Not Likely to Adversely Affect
nm	Nautical Mile(s)
NMFS	National Marine Fisheries Service (aka NOAA Fisheries)
NOAA	National Oceanic and Atmospheric Administration
PIRO	Pacific Islands Regional Office
PTS	Permanent Threshold Shift
RCCTO	U.S. Army Rapid Capabilities and Critical Technologies Office

RMI	Republic of the Marshall Islands
RMS	Root Mean Square
ROV	Remotely Operated Vehicle
RTS	Ronald Reagan Ballistic Missile Test Site (aka Reagan Test Site)
SEL	Sound Exposure Level
SPL	Sound Pressure Level
SSP	Strategic Systems Programs
TTS	Temporary Hearing Effect Threshold
UES	USAKA Environmental Standards
U.S.	United States
USAF	U.S. Air Force
USAG-KA	United States Army Garrison – Kwajalein Atoll
USAKA	U.S. Army Kwajalein Atoll
USASMDC	Space and Missile Defense Command, US Army
VAFB	Vandenberg Air Force Base
yd^2	Square Yard(s)
μPa	Micro-Pascal

1 INTRODUCTION

The proposed action involves the U.S. Air Force's (USAF) development and testing of a new Intercontinental Ballistic Missile (ICBM) weapon system for the proposed Ground Based Strategic Deterrent (GBSD) Test Program. System tests would start in FY 2024 and continue until FY 2029. Each missile test would launch from Vandenberg Air Force Base (VAFB), California, and travel across a broad ocean area (BOA) of the Pacific Ocean. Payload impact would occur at target impacts at United States Army Garrison – Kwajalein Atoll (USAG-KA) sites in the Republic of the Marshall Islands (RMI). Implementation of the test program would also include facility construction or modifications at Hill Air Force Base (HAFB), VAFB, and Dugway Proving Ground.

The GBSD represents the modernization of the land-based nuclear arsenal and would eventually replace the aging Minuteman III (MMIII) weapon system, which has exceeded its designed life expectancy. While the system remains an active, viable deterrent for the United States, many components are becoming obsolete and unsupportable, resulting in continual upgrades to maintain system reliability and performance. It is in the best interest of national security to replace the MMIII weapon system. However, before the USAF can remove the MMIII weapon system from active status and deploy the new weapon system, system development and testing under the proposed GBSD Test Program must first occur. The GBSD tests will be similar to and a crucial step in the developmental process following the MMIII flight tests, which are conducted yearly.

The Endangered Species Act (ESA) would apply for the portions of the action that would take place in and over United States (U.S.) territory and international waters, but not for the portions of the action that would take place within the RMI. The Government of the RMI has agreed to allow the U.S. Government to use certain areas of Kwajalein Atoll (collectively referred to as U.S. Army Kwajalein Atoll or USAKA). "USAKA" is defined as "…the [USAKA]-controlled islands and the Mid-Atoll Corridor, as well as all USAKA-controlled activities within the [RMI], including the territorial waters of the RMI". The USAKA controls 11 islets around the atoll. The relationship between the U.S. Government and the Government of the RMI is governed by the Compact of Free Association (Compact), as Amended in 2003 (48 USC 1681). Section 161 of the Compact obligates the U.S. to apply the National Environmental Policy Act of 1969 (NEPA) to its actions in the RMI as if the RMI were a part of the U.S. However, the ESA does not apply within the RMI. Instead, the Compact specifically requires the U.S. Government to develop and apply environmental standards that are substantially similar to several U.S. environmental laws, including the ESA and the Marine Mammal Protection Act (MMPA). The standards and procedures described in the Environmental Standards and Procedures for USAKA Activities in the RMI (aka USAKA Environmental Standards or UES, 15th Edition) were developed to satisfy that requirement. Therefore, the US Government must apply the UES to its activities within the RMI. Because the ESA and UES both apply to this action, this biological opinion was written in a manner that considers and complies with each of those standards, as applicable.

Section 7(a)(2) of the Endangered Species Act (ESA) of 1973, as amended (ESA; 16 U.S.C. 1536(a) (2)) requires each federal agency to ensure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of critical habitat of such species.

When a federal agency's action "may affect" a listed species or its designated critical habitat, that agency is required to consult formally with the National Marine Fisheries Service or the U.S. Fish and Wildlife Service, depending upon the endangered species, threatened species, or designated critical habitat that may be affected by the action (50 CFR 402.14(a)). Federal agencies are exempt from this general requirement if they have concluded that an action "may affect, but is not likely to adversely affect" endangered species, threatened species or their designated critical habitat, and NMFS or the FWS concur with that conclusion (50 CFR 402.14 (b)).

If an action is likely to adversely affect a listed species, the appropriate agency (either NMFS or FWS) must provide a Biological Opinion (Opinion) to determine if the proposed action is likely to jeopardize the continued existence of listed species (50 CFR 402.02). "Jeopardize the continued existence of" means to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species.

The U.S. Air Force Nuclear Weapons Center is the lead agency and action proponent for the Proposed Action, along with the United States Army Space and Missile Defense Command (USASMDC) as a participating Agency. The UES requires all parties of the U.S. Government involved in this project to consult or coordinate with the NMFS and the FWS to conserve species and habitats of special concern at USAKA. We will address the USASMDC exclusively in this document as the participating agency. Section 3.4 of the UES establishes the standards and procedures to be followed "…to ensure that actions taken at USAKA will not jeopardize the continued existence of these species or result in destroying or adversely changing the habitats on which they depend." Section 3.4 is derived primarily from the regulations implementing the ESA, other U.S. regulations, and wildlife protection statutes of the RMI. As such, the list of UES consultation species includes all species present in the RMI that are listed under the ESA (including those that are candidates or are proposed for listing), all marine mammals protected under the MMPA, and all species and critical habitats as designated under RMI law. However, no critical habitat has yet been designated in the RMI.

Under the UES, "the final biological opinion shall contain the consulting agency's opinion on whether or not the action is likely to jeopardize the continued existence of a species or to eliminate a species at USAKA, or to eliminate, destroy, or adversely modify critical habitats in the RMI" (UES at 3-4.5.3(e)). Although the UES does not specifically define jeopardy, the Compact clearly intends that the UES provide substantially similar environmental protections as the ESA. We interpret this to include adoption of the ESA definition of jeopardy, as described above, and this review relies upon the ESA definition of jeopardy to reach its final conclusions.

This document represents NMFS' final Biological Opinion of the effects on marine species protected under the ESA and the UES that may result from the GBSD tests from VAFB, California, to the impact sites in the Kwajalein Missile Impact Scoring System (KMISS) deeper waters, in the vicinity of, and on Illeginni Islet in Kwajalein Atoll. This Opinion is based on the review of: the USAF and USASMDC November 5, 2020, Biological Assessment (BA) for the proposed action; recovery plans for U.S. Pacific populations of ESA-listed marine mammals, sea turtles, and elasmobranchs; published and unpublished scientific information on the biology and ecology of ESA-listed marine species, UES-consultation marine species, and other marine species of concern in the action area; monitoring reports and research in the region; biological opinions on similar actions; and relevant scientific and gray literature (see Literature Cited).

1.1 Consultation History

In 2015, the USAF consulted with NMFS on the effects of MMIII Modification activities on UES-listed consultation species in the Action Area. On July 29, 2015 NMFS PIRO issued a Biological Opinion (BO) for MMIII activities that included up to five tests per year with Reentry Vehicle (RV) impacts on land at Illeginni Islet (PIRO-2015-9650). In this BO, NMFS concluded that the proposed MMIII action was not likely to adversely affect 43 consultation species and would have no effect on critical habitats designated in the RMI. NMFS concluded that the debris and ejecta from crater formation were LAA 15 UES-consultation coral species and top shell snails (*Tectus niloticus*), but not likely to result in the jeopardy of any of these UES consultation species (NMFS 2015a).

- After NMFS issued the 2015 BO for the MMIII Modification action, the USAF changed the location of proposed RV impacts and additional species were listed as consultation species under the UES. The USAF removed Illeginni Islet land impact from the MMIII action and proposed RV impacts in the KMISS and nearby deep ocean waters east of Gagan Islet only. Therefore, the USAF revised their effect determinations for the MMIII Modification action, concluding that the action was not likely to adversely affect UES consultation species in the Action Area. On April 17, 2019 NMFS amended the 2015 consultation and concurred with the USAF determination that the MMIII Modification project, with up to five tests per year between fiscal year (FY) 2019 and 2022 and four tests per year through 2030, may affect but would not likely adversely affect ESA or UES listed consultation species (I-PI-18-1732-AG).

On July 23, 2020 NMFS PIRO Biologists met with USASMDC and KFS, LLC personnel to conduct early coordination and discuss general information about the GBSD Test Program project as well as a consultation plan for the Proposed Action. During this meeting, parties discussed the similarity of the Proposed Action activities to those evaluated for the MMIII Fuze Modernization Program.

On November 16, 2020 we received from the USAF and USASMDC this consultation request in a letter dated November 5, 2020 stating that they had determined that the GBSD Test Program (the proposed action) may affect, but is not likely to adversely affect 24 marine ESA and/or UES consultation species (Table 1), and requested consultation for those species.

In the BA, the USAF/USASMDC further determined that the proposed action was likely to adversely affect (LAA) the 11 marine UES consultation species listed in Table 2. Formal consultation was initiated on November 5, 2020, resulting in this Opinion.

Table 1. Marine consultation species not likely to be adversely affected by the proposed action

Scientific Name	Species	ESA	MMPA	CITES	RMI
Sea Turtles					
Chelonia mydas	Central Western Pacific Green Sea Turtle DPS	Endangered		X	X
Eretmochelys imbricata	Hawksbill Sea Turtle	Endangered		X	X
Marine Mammals					
B. musculus	Blue Whale	Endangered	X	X	X
B. physalus	Fin Whale	Endangered	X	X	
Delphinus delphis	Short-beaked common Dolphin				X
Feresa attenuata	Pygmy Killer Whale		X		
Globicephala macrorhynchus	Short-finned Pilot Whale		X		
Grampus griseus	Risso's Dolphin		X		
Kogia breviceps	Pygmy Sperm Whale			X	
Megaptera novaeangliae	Western North Pacific Humpback Whale DPSs	Endangered	X	X	
Mesoplodon densirostris	Blainville's Beaked Whale		X		
Orcinus orca	Killer Whale		X		
Peponocephala electra	Melon-Headed Whale		X		
Physeter macrocephalus	Sperm Whale	Endangered	X	X	X
Stenella attenuata	Spotted Dolphin				X
S. coeruleoalba	Striped Dolphin				X
S. longirostris	Spinner Dolphin		X		X
Tursiops truncatus	Bottlenose Dolphin, Pacific		X		
Fish					
Alopias superciliosus	Bigeye Thresher Shark				X
Manta alfredi	Reef manta ray				X
M. birostris	Giant manta ray				
Sphyrna lewini	Indo-West Pacific Scalloped Hammerhead Shark DPS	Threatened			X
Thunnus orientalis	Pacific bluefin tuna				X
Carcharhinus longimanus	Oceanic white-tip shark	Threatened			

Table 2. Marine consultation species likely to be adversely affected by the proposed action

Scientific Name	Species	ESA	MMPA	CITES	RMI
Fish					
Cheilinus undulatus	Humphead Wrasse			X	X
Corals					
Acropora microclados	No Common Name			X	X
A. polystoma	No Common Name			X	X
Cyphastrea agassizi	Agassiz's coral			X	X
Heliopora coerulea	Blue coral			X	X
Pavona venosa	No Common Name			X	X
Turbinaria reniformis	No Common Name			X	X
Pocillopora meandrina	Cauliflower Coral	Candidate			X
Mollusks					
Tectus niloticus	Top Shell Snail				X
Hippopus hippopus	Giant clam	Candidate			
Tridacna squamosa	Giant clam	Candidate			X

The USAF also has determined that the Proposed Action launch activities would have no effect on ESA-listed species or designated critical habitats at VAFB and that no consultation with NMFS is required for launch activities at VAFB. Guadalupe fur seals (*Arctocephalus townsendi*) are not likely to occur in the Action Area at VAFB, and no part of the Proposed Action would affect designated critical habitat for black abalone (*Haliotis cracherodii*) or leatherback sea turtles (*Dermochelys coriacea*). *In 2015, the USAF determined that MMIII launch activities would have no effect on ESA listed species under NMFS jurisdiction at VAFB (USAF 2020b, NMFS 2015a).*

On January 11, 2020 NMFS emailed USAF and requested the USAF to consider changing their species determination for the humphead wrasse from NLAA to LAA, and also to confirm the NE determination for the following species: green sea turtle (North Pacific DPS), olive ridley sea turtle, sei whale, and 15 coral: *Acanthastrea brevis, Acropora aculeus, A. aspera, A. dendrum, A. listeri, A. speciosa, A. tenella, A. vaughani, Alveopora verrilliana, Leptoseris incrustans, Montipora caliculata, Pavona cactus, P. decussata, Turbinaria mesenterina, and T. stellulata*), two mollusk species (*Pinctada margaritifera* and *Tridacna gigas*). The USAF responded via email on January 12, 2020 confirming their agreement to change the humphead wrasse species determination from NLAA to LAA, and also confirmed the NE determination for the above species.

2 DESCRIPTION OF THE PROPOSED ACTION

The proposed action is described in detail in the USAF/USASMDC BA. The proposed flight tests would implement flight testing and booster development of the proposed GBSD weapon system that is intended to replace the aging MMIII weapon system. Testing will verify and validate system performance capabilities (baseline requirements), assess attainment of technical design parameters, and determine whether the system is operationally effective, survivable, and safe for its intended use. The proposed missile tests would launch from Vandenberg Air Force Base (VAFB), and would travel across a broad ocean area (BOA) of the Pacific Ocean with payload impact occurring on Illeginni Islet, in the vicinity of Illeginni Islet, and in the KMISS area in the RMI (Figure 1). In addition, the test program would also include facility construction/modifications at Hill Air Force Base (HAFB), VAFB, and Dugway Proving Ground. No ESA listed threatened, endangered, or candidate species or designated critical habitats are known to occur at or near any of the proposed GBSD Test Program sites on Dugway Proving Ground or on HAFB (USAF 2016; U.S. Army 2016; U.S. Army 2020). Infrastructure development would occur on land and would have no effect on any ESA or UES listed species; therefore, this part of the proposed action will not be discussed further in this Opinion.

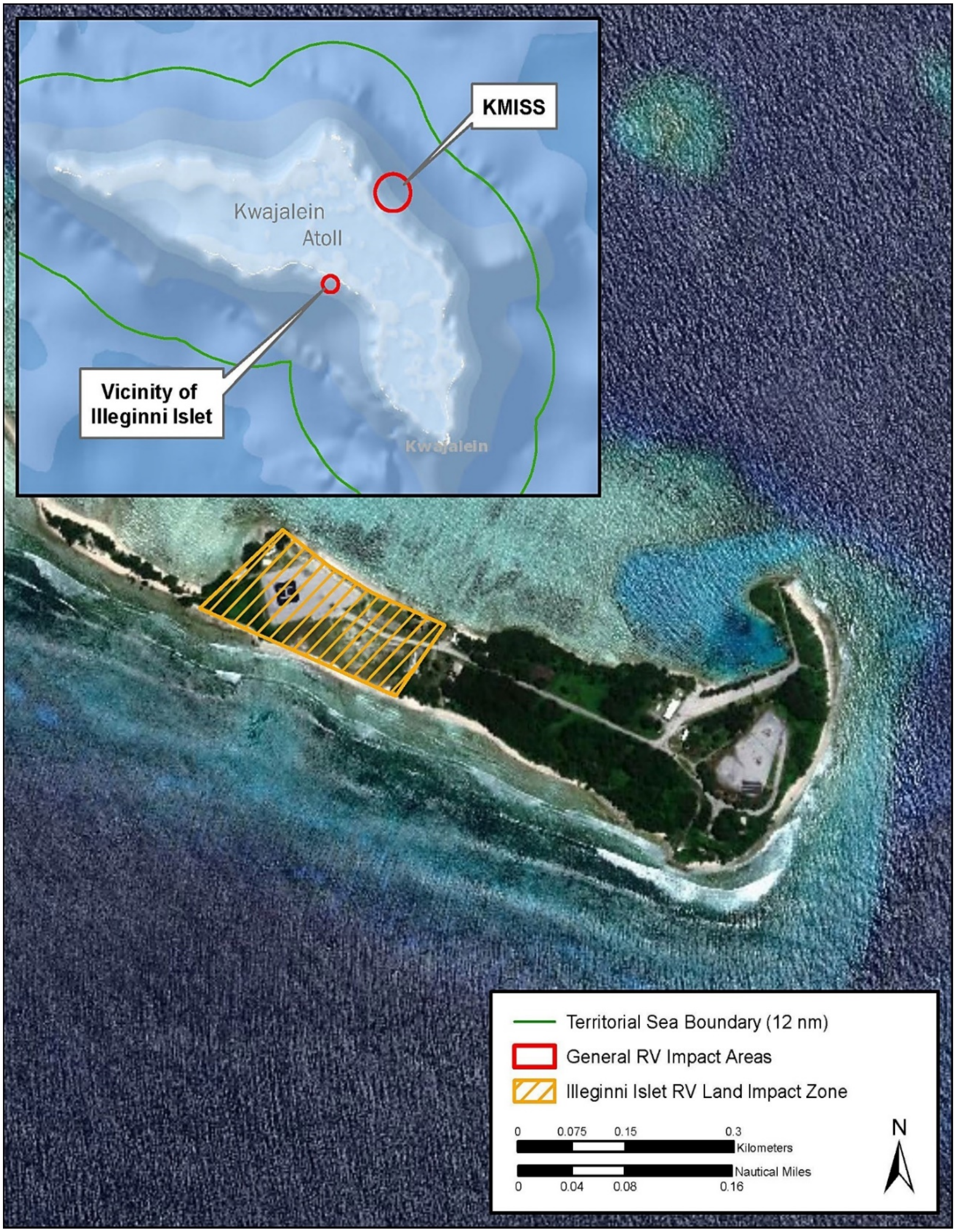

Figure 1. GBSD Reentry Vehicle (RV) Impact Areas at Kwajalein Atoll, RMI.

The proposed GBSD flight test activities include pre-flight preparation activities at Kwajalein Atoll, multiple flight tests in and above Kwajalein Atoll (including RV impact), payload impact, post-flight impact data collection, and post-flight operations at Kwajalein Atoll, debris recovery, and clean-up operations at USAKA. There are currently up to six GBSD flight tests planned per year (for a total of 28 GBSD flight tests) between FY 2024 and FY

2029, but the USAF anticipates up to nine tests per year (launching from VAFB) to account for shifts in scheduling and planning (Table 3). A portion of these tests would involve flight termination at USAG-KA; however, since the number of tests with terminal impact at Kwajalein remains unspecified, these analyses assume that all tests could use USAG-KA. The USAF currently anticipates only one land impact flight test at Illeginni Islet for the GBSD Test Program, but up to three total land RV impacts may be possible through FY 2029.

Deployment of the new GBSD weapon system cannot occur until it has been adequately tested and proven sufficiently developed for operational use; therefore, both GBSD and MMIII flight test activities and related operations would overlap at HAFB, VAFB, and USAG-KA. This testing would overlap for up to 10 years, or until decisions are made to remove the MMIII weapon system from active status.

Table 3. Proposed Number of GBSD and MMIII Flight Tests by Fiscal Year.

Test Program	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29
GBSD	0	0	0	4	4	5	6	5	4
MMIII	4	5	3	4	4	4	3	3	3
Total	4	5	3	8	8	9	9	8	7

The following subsections include descriptions of the launch vehicle, pre-flight operations, flight, terminal phase operations, and post-flight operations.

Launch Vehicle Description

The specific design of the launch vehicle/proposed GBSD weapon system has not yet been confirmed; however, the plan is for the design of the launch vehicles to be sized to fit within existing MMIII launch facilities (LFs) at VAFB. The booster would use a solid propellant composition with similar properties to that of the MMIII booster. Comparable to the MMIII flight test missile, the GBSD flight test missile would carry a post boost vehicle on top of the booster that includes a propulsion system rocket engine with liquid hypergolic propellants, missile guidance set, and reentry system (Figure 2).

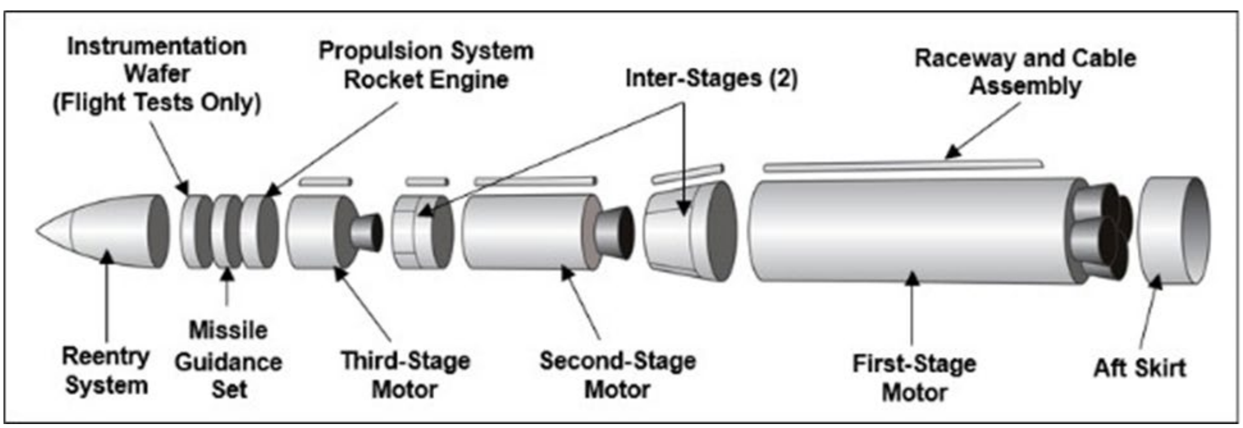

Figure 2. Minuteman III Missile Components. (Source: USAF 2004, 2013, 2020b)

Similar to the MMIII system, the GBSD weapon system design is expected to use ordnance including a shroud ejection motor initiator, motor igniter assemblies, gas generators, and a flight termination system destruct package.

Although the GBSD payload may be of a new design, it would contain one to three test RVs which would be the same or similar to those used for MMIII flight testing. The MMIII reentry system was designed to contain one to three Mark 21 or Mark 12A RVs with a two-piece protective shroud (Figure 3). Test RVs are used for the annual MMIII flight tests, and the same is also expected for GBSD testing.

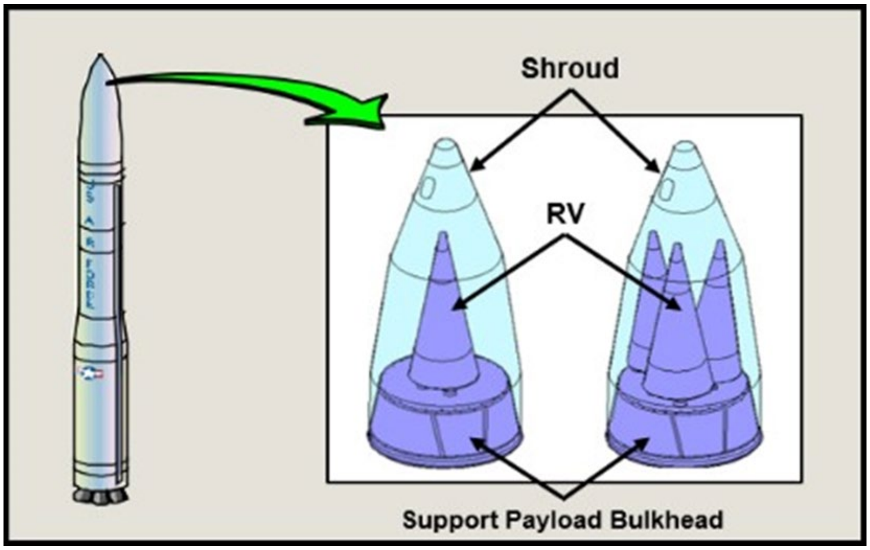

Figure 3. Minuteman III Payload/Reentry System. (Source: Modified from USAF 2013, 2020b)

Typical test RVs, similar to the MMIII vehicles, do not contain any fissile materials but do contain some hazardous materials that would include silver zinc and thermal batteries, asbestos, depleted uranium, and other heavy metals (Table 4).

Table 4. MMIII Reentry Vehicle Characteristics (Sources: USAF 2004, USAF 2020a, USAF 2020b)

Component	Description
Batteries	• Mark 12A RVs contain one silver zinc battery, approximately 0.7 kilogram (1.6 pounds) • Mark 21 RVs contain one silver zinc and one thermal battery, totaling approximately 1.1 kilograms (2.4 pounds)
Hazardous Materials	All test RVs typically include: • 8 to 623 grams (1 to 22 ounces) of asbestos • approximately 1 to 10 grams (<1 ounce) each of beryllium (Be), cadmium (Cd), and chromium (Cr) • approximately 136 grams (45 ounces) of lead (Pb) • less than 84 kilograms (185 pounds) of depleted uranium (DU)

Pre-flight Preparations:

Pre-flight preparations would be the same as, or similar to, those conducted for the MMIII flight tests. Pre-flight activities would occur at the KMISS site, on land at Illeginni Islet, and in Kwajalein Atoll waters. In the vicinity of Illeginni Islet, pre-flight activities would include several vessel round-trips and helicopter trips to the RV impact location for personnel and equipment transport. For tests conducted at Illeginni Islet, portable camera stands would be set up on the western end of Illeginni Islet to record the flight test prior to the test. A barge or landing raft would be used to transport test equipment to Illeginni Islet. It is anticipated that, similar to other flight tests (such as the MMIII and FE-2 programs) with payload impact at Illeginni Islet, there would be increased human activity on Illeginni Islet over a three-month period (USAF 2020).

Launch: The GBSD weapon system RVs will be launched from land at VAFB, California and enter an over-ocean flight phase within seconds after the launch. *As described in the Consultation History, the USAF and USASMDC have concluded that all Proposed Action launch activities at VAFB are covered under existing programmatic consultations for ongoing launch activities at VAFB, and therefore will not be covered under or discussed further in this consultation.*

Over-Ocean Flight: After launching, a series of ground, sea, and/or air based sensors would monitor the GBSD vehicle during flight and collect data on vehicle flight and system performance (details below). Each flight test may have up to three RVs which would impact at USAG-KA. It is expected that most test RVs would be targeted at the KMISS ocean area just east of Gagan Islet, or within deep ocean waters in the vicinity of Illeginni Islet on the western side of Kwajalein Atoll (Figure 1). For flight tests terminating at Kwajalein Atoll, only test RVs would impact within RMI territorial waters or on land at Illeginni Islet. For security purposes, all other activities relating to over-ocean flight would occur over international waters and are described and evaluated in a separate classified annex to the GBSD Test Program Environmental Assessment, and will therefore not be discussed in this Opinion (USAF 2020a).

Testing at the KMISS ocean area would be conducted in the same manner as for the current/ongoing MMIII flight tests, while testing in the vicinity of Illeginni Islet would be conducted similarly to what was previously done under the MMIII program (USAF 2020b; USAF 2004, USAF 2015). The KMISS RV impact area would be in deep ocean waters east of Kwajalein Atoll. At Illeginni Islet, RVs would typically impact in ocean waters southwest of the islet. The RV impact zone on Illeginni Islet would only be used for up to three total tests through FY 2029, and only three total RV impacts would be expected. There is a small risk that a potential land impact test might result in an RV strike near the shallow waters or reef flats adjacent to the western end of Illeginni. For MMIII tests, the USAF estimated the probability of a shallow water or reef RV impact to be between 0.10 and 0.20 (USAF 2015).

A crater would form with soil, rubble, and RV fragments being ejected outward from the impact site as a result of an RV strike at Illeginni Islet. Prior MMIII RV tests have resulted in craters 6.1 to 9.1 m in diameter and 2.1 m to 3.0 m deep (USAF 2015). Any RV components or substances would be ejected outward from the RV impact point. Based on observations from MMIII and other payload testing at Illeginni Islet, most of the RV materials and substrate ejecta would remain close to edge of the crater. The density of ejecta would be expected to decrease with distance from the impact point. For MMIII and other program flight tests (such as the FE-2 tests), ejecta resulting from crater formations was estimated to extend no more than 60 to 91 m from the impact location (USAF 2015, U.S. Navy 2019) and would be primarily within an area 120 degrees downrange along the flight path (USAF 2015) (Figure 4).

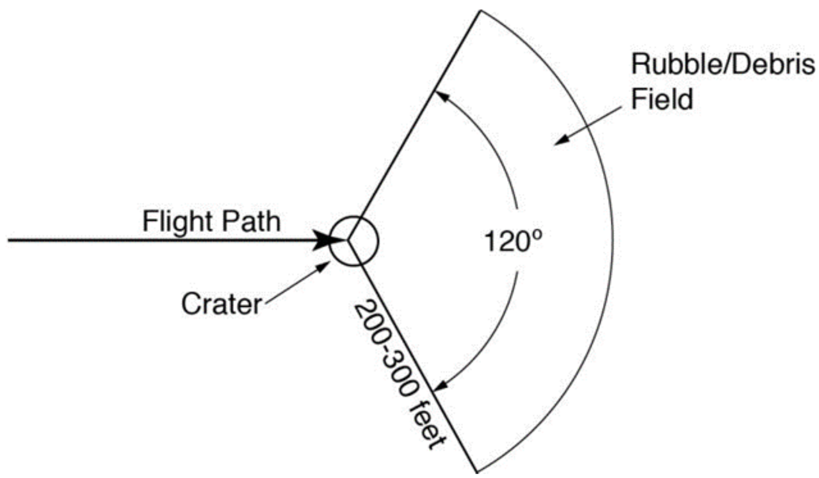

Figure 4. Approximate Debris Field for Reentry Vehicle Land Impacts. (Source: USAF 2015)

A land impact test that strikes the shoreline could result in the dispersal of soil and rubble onto the shallow near shore reef flat. Although not planned, an RV shallow water impact (water depths of 3.0 m less) on the reef at Illeginni Islet could create a crater 3.0 to 4.6 m wide and 0.6 to 1.2 m deep (as estimated for MMIII testing). Prior tests have shown that no craters are formed in waters deeper than 3.0 m (USAF 2015). During most GBSD tests, RVs would remain intact until ocean water or land impact. However, up to two test RVs per year may contain an explosive charge for purposes of conducting a high fidelity test. During such tests, the RV may detonate upon contact with the land or ocean waters or may detonate at some altitude in air (airburst). Because of the RV's hypersonic velocity at time of detonation, the resulting debris (mostly aerosolized) impacts in a focused area at the impact site (USAF 2015). For MMIII, the USAF estimated that the energy associated with high fidelity test debris is less than the energy associated with a conventional RV impact (USAF 2015).

If the launch vehicle were to deviate from its course or should other problems occur during flight that might jeopardize public safety, the destruct devices (in the form of linear explosive assemblies) would separate the stages, split the motor casings, and stop forward thrust. This action would initiate a predetermined safe mode for the vehicle, causing it to terminate flight and fall into the ocean. No termination debris would be expected to fall on land. The need for flight termination is unplanned and would be an unexpected and unlikely event.

Sensor Coverage:

The flight paths would initiate from VAFB, travel across the BOA, and continue to USAKA in the RMI. A series of ground, sea, and/or air based sensors would monitor the GBSD vehicle during flight and collect data on vehicle flight and system performance. Up to 17 Lawrence Livermore National Laboratory (LLNL) sensor rafts stored at USAG-KA would be temporarily deployed in ocean waters near the RV impact location. The rafts measure approximately 2.7 m wide and 4.6 m long, and contain various sensors including neutron detectors, hydrophones, video equipment, and cameras (Figure 5). The rafts generally use battery-powered tolling motors for station-keeping to ensure proper positioning for the flight tests (USAF 2020b). No anchors would be used to maintain the raft positions. Rafts would be deployed from a landing craft utility or similar vessel and would be placed in water depths at least 3 m.

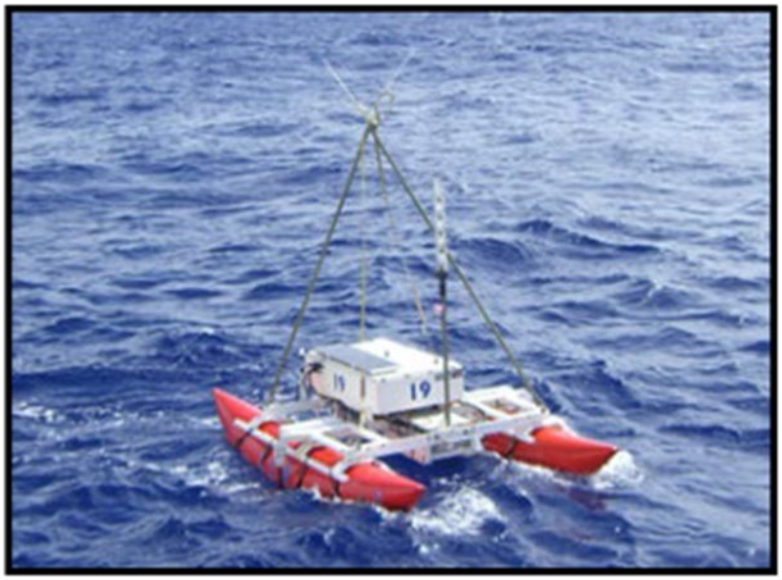

Figure 5. Representative Sensor Raft System. (Source: USAF 2010)

<u>Post-flight Operations:</u>

Post-flight operations would involve post-test recovery and clean-up, which would include vessel traffic and personnel recovering GBSD post-flight debris at Illeginni islet either manually or with heavy equipment (similar to that used during site preparation). LLNL sensor rafts described above would be recovered with a landing craft. Landing craft utilities or other vessels would be used to transport cleanup and recovery equipment (such as a backhoe or grader) from Kwajalein Islet to Illeginni Islet. Visible RV debris on land, including hazardous materials, would be cleaned up by hand. Most RV debris would normally be found in the crater and a backhoe may be used to excavate the craters. The material excavated from these craters would be screened for RV debris and would then be backfilled with soil and rubble that was ejected around the wall of the crater. All recovered RV and other man-made debris would be shipped back to Kwajalein Islet or the United States.

Although lagoon and ocean reef flats will not be intentionally targeted during GBSD testing, recovery and cleanup of RV debris in these areas would be necessary if RV debris entered these areas due to a shoreline land impact or an unintentional reef impact. RV debris recovery would be attempted in areas within 152 to 305 m of the shoreline on the lagoon side of Illeginni Islet (USAF 2004). In shallow, nearshore areas recovery would be conducted similarly to land operations when tide conditions and water depth permit (USAF 2004, USAF 2015). If recovery operations were necessary in lagoon or ocean reef flats, USAF and USAG-KA personnel would coordinate with NMFS and USFWS to identify and use access corridors to the crater site to avoid unnecessary and accidental impacts to protected species and sensitive habitats. If RV debris were in deeper waters, a USAG-KA dive team would be brought in to conduct underwater searches (USAF 2004). A ship would also be used for recovery operations. A remotely operated vehicle would first be used to locate the debris field and then divers in scuba gear would recover debris manually (USAF 2004). In the event of an unplanned lagoon or reef flat impact, it is predicted that rubble ejected from an impact crater larger than one inch would be found within a 1.5–3 m radius around the crater rim (USAF 2015).

No post-test recovery and clean-up activities are anticipated for GBSD flight tests conducted at the KMISS site. For a nominal/planned mission, RVs that impact in the deep ocean waters/ocean side of Illeginni Islet are not recovered. Searches for RV debris would only be attempted out to depths of 15 to 30 m in an operation similar to lagoon recovery operations (USAF 2004).

Further, the USAF would prepare a post-test recovery/cleanup plan detailing specific actions which would be taken, including the Mitigation Measures/Best Management Practices (BMPs) listed below, to avoid impacts to listed species. The Mitigation Measures listed below would be implemented as part of GBSD test program and are very similar to those implemented for MMIII (USAF 2015, USAF 2020b) and other recent test programs with payload impacts at Illeginni Islet (U.S. Navy 2019, U.S. Navy 2017). The following measures would be implemented as part of the Proposed Action and would be included in the DEP for GBSD Test Program activities at Kwajalein Atoll.

<u>Mitigation Measures/Best Management Practices (BMPs):</u>

Marine Mammal and Sea Turtle Monitoring

- During travel to and from impact zones, including Illeginni Islet, ship personnel would monitor for marine mammals and sea turtles to avoid potential ship strikes. Vessel operators would adjust speed or raft deployment based on expected animal locations, densities, and/or lighting and turbidity conditions.
- USAG-KA personnel would conduct a helicopter or fixed-wing aircraft overflight of the impact area three times over the week preceding a flight test and as close to launch as safely practical to survey for marine mammals and sea turtles. The final overflight would be within one day of the proposed launch. If personnel observe marine mammals or sea turtles in the vicinity, they would report such findings to the USAG-KA Environmental Office.
- Any observations of marine mammals or sea turtles during ship travel or overflights would be reported (including location, date, time, species or taxa, and number of individuals) to the USAG-KA Environmental Engineer who would maintain records of these observations and report sightings to NMFS and/or USFWS.
- Pre-flight monitoring by qualified personnel will be conducted on Illeginni Islet for sea turtles or sea turtle nests. For at least eight weeks preceding the launch, Illeginni Islet would be surveyed by pre-test personnel for sea turtles, sea turtle nesting activity, and sea turtle nests. If possible, personnel will inspect the area within days of the launch. If sea turtles or sea turtle nests are observed near the impact area, observations would be reported to appropriate test and USAG-KA personnel for consideration in approval of the launch, and to USFWS and NMFS.
- Personnel will report any observations (including location, date, time, species, and number of individuals) of sea turtles or sea turtle nests on Illeginni Islet to the USAG-KA Environmental Engineer who would maintain records of these observations and report sightings to USFWS.
- Although unexpected, any dead or injured marine mammals or sea turtles sighted by post-flight personnel would be reported to the USAG-KA Environmental Office and

USASMDC, 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.

Hazardous Materials Measures

- 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.
- Any accidental spills from support equipment operations would be contained and cleaned up and 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 Kwajalein Environmental Emergency Management Plan 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 Kwajalein Atoll will undergo inspection prior to shipment to prevent the introduction of alien species into Kwajalein Atoll.
- Following a land-impact test, the USAF and USAG-KA would collect soil and groundwater samples at various locations around the impact site and test the samples for beryllium (Be), DU, and other metals. Testing results that exceed UES criteria would require a soil investigation as detailed in the UES and may require subsequent soil removal or other remediation.

Reef Protection Measures

- To avoid impacts on coral heads in waters near Illeginni Islet, sensor rafts would not be located in waters less than 3 m deep.
- When feasible, within one day after the land impact test at Illeginni Islet, USAG-KA environmental staff would survey the islet and the near-shore waters for any injured wildlife, damaged coral, or damage to sensitive habitats (i.e., reef habitat). Any impacts to biological resources would be reported to the Appropriate Agencies, with USFWS and NMFS offered the opportunity to inspect the impact area to provide guidance on mitigations.
- If an inadvertent impact occurs on the reef, reef flat, or in shallow waters less than 3 m deep, 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 test. The inspectors would assess any damage to coral and other natural and biological resources and, in coordination with USAF, USAG-KA, and RTS representatives, decide on any response measures that may be required.
- If any man-made debris were to enter the marine environment and divers were 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.

General Measures at Illeginni Islet

- 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, 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.
- Debris recovery and site cleanup would be performed for the land impact. To minimize long-term risks to marine life, all visible project-related man-made debris would be recovered during post-flight operations. In all cases, recovery and cleanup would be conducted in a manner to minimize further impacts on biological resources.
- For recovery and rehabilitation of any injured migratory birds or sea turtles found at Illeginni Islet, USFWS and NMFS would be notified to advise on best care practices and qualified biologists would be allowed to assist in recovering and rehabilitating any injured sea turtles found.
- 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.

2.1 Interrelated/Interdependent Actions

Military training and testing at Kwajalein Atoll has been ongoing since World War II. Testing of missile programs at Kwajalein began in 1959 for the Nike Zeus missile program. The Minuteman (MM) I program began in 1962, MMII began in 1965, and MMIII began in 1970. In addition to the MM program, anti-ballistic missile (e.g. Terminal High Altitude Area Defense (THAAD)), and other missile development and testing take place at the RTS, along with other military training and testing activities, and commercial missile launches. If it were not for these numerous activities, it is doubtful that the facilities at USAKA and RTS would be required. Therefore actions to develop and maintain USAKA and RTS facilities and infrastructure, and to support the various missions, are interrelated and/or interdependent with the training and testing activities that occur at the USAKA and RTS. However, much of the infrastructure and facilities are designed to support numerous programs and missions, with few being project-specific. Therefore, support activities that are solely attributable to the GBSD weapon system constitute a small portion of the total that occur at USAKA and RTS in support of the site's numerous missions. Further, per the Document of Environmental Protection (DEP) procedures outlined in the UES, any USAKA and RTS actions that may affect the USAKA environment require structured environmental review, with coordination and/or consultation as appropriate. Based on this, we expect that interrelated or interdependent actions that may be solely attributable to the GBSD flights would be virtually inseparable from the routine activities at USAKA and RTS, and any impacts those actions may have would be considered through the DEP procedures outlined in the UES.

2.2 Action Area

The action area for this consultation begins at the launch site on VAFB, California to the terminal end of the GBSD test flights within the RMI territory, which includes the RV impact sites at: 1) in ocean waters of the KMISS area; 2) in ocean waters in the vicinity of Illeginni Islet; or 3) on land at Illeginni Islet. The GBSD launch vehicle would launch from VAFB, California and likely consist of a three stage booster system with an experimental payload. As described above, to comply with GBSD Test Program security classification requirements regarding missile flight paths and downrange testing, only GBSD downrange target locations at USAG-KA are described and analyzed in this Opinion. Other downrange actions and locations are described and analyzed in a separate, classified annex to the GBSD Test Program Environmental Assessment / Overseas Environmental Assessment (USAF 2020a). GBSD spent booster motors, post boost vehicle components, and test RVs would be expected to impact primarily in ocean waters away from land areas. Furthermore, although the launch activities will have no effect on listed species and are not discussed in this consultation, it is still included as part of the action area.

As mentioned above, testing in the RMI would be conducted in the same manner as for the ongoing MMIII flight tests in the KMISS area (USAF 2020b), and testing on and in the vicinity of Illeginni Islet would be conducted similarly to what was previously done under the MMIII program (USAF 2004, USAF 2015). The KMISS impact area currently used for MMIII is in deep ocean waters east of Kwajalein Atoll, at least 5.6 km (3 nm) offshore of Gagan Islet. The RV impact zone in the vicinity of Illeginni Islet would be in ocean waters southwest of the islet. For MMIII testing, the test RVs were expected to typically impact up to approximately 792 meters (2,600 ft) from the islet. The RV impact zone on Illeginni Islet is an area on the non-forested, northwest end of the islet that has been used for DoD testing for several decades.

The action area covered under this Opinion (RV impact areas) are not located in any ESA critical habitats.

3 SPECIES AND CRITICAL HABITATS NOT LIKELY TO BE ADVERSELY AFFECTED

As explained above in Section 1, the USAF/USASMDC determined that the proposed action was not likely to adversely affect (NLAA) the 35 consultation species listed in Tables 1 and 2. This section serves as our concurrence under section 7 of the ESA of 1973, as amended (16 U.S.C. §1531 et seq.), and under section 3-4.5.3(d) of the UES, 15th Edition, with the USAF/USASMDC's determination.

The UES does not specifically define the procedure to make a NLAA determination. However, the Compact clearly intends that the UES provide substantially similar environmental protections as the ESA. We interpret this to include adoption of the ESA NLAA determination process. In order to determine that a proposed action is not likely to adversely affect listed species, under the ESA, we must find that the effects of the proposed action are expected to be insignificant, discountable, or beneficial as defined in the joint FWS-NMFS Endangered Species Consultation Handbook. Insignificant effects relate to the size of the impact and should never reach the scale where take occurs; discountable effects are those that are extremely unlikely to occur; and beneficial effects are positive effects without any adverse effects (FWS and NMFS 1998). Many of the stressors for the Proposed Action are expected to be similar to the MMIII action and other test programs; therefore, portions of the MMIII Modification BA (USAF 2015), the NMFS BO on that action (NMFS 2015a), and Flight Experiment 2 (FE-2) BA (U.S. Navy 2019) are referenced and used in this analysis. Each phase has potential stressors; however, only stressors associated with terminal flight and impact in the RMI will be discussed and listed below, which are based on what the missile is doing and on activities done to support the test. As mentioned earlier in this Opinion, the launch activities portion of the action will not be discussed in this consultation, as the USAF has determined that the launch will have no effect on any listed species and critical habitat. Over-ocean flight activities will also not be discussed due to security measures; however, based on effects determinations made in previous consultations (such as with the MMIII program, Flight Experiment 1 (FE-1), and FE-2 tests) with similar test flights impacting the RMI, we expect similar effects to listed species.

No critical habitat has been designated in the RMI, and the action area covered under this consultation does not occur within any ESA-listed species critical habitats; therefore, no designated critical habitat occurs in the Action Area and there would be no effects to critical habitat.

Reentry Vehicle Impact in the RMI: The potential stressors during payload impact and preparation and restoration work in the KMISS, vicinity of Illeginni Islet, and Kwajalein Atoll are:

a) Exposure to elevated noise levels;
b) Direct contact from payload impacts;
c) Exposure to hazardous materials;
d) Disturbance from human activity and equipment operation; and
e) Collision with vessels.

NMFS has determined an additional stressor from this proposed action:

a) Long-term addition of man-made objects to the ocean.

Each of these stressors are addressed below to determine whether or not individuals of any of the ESA-listed and UES-protected marine species considered in this consultation are likely to be adversely affected by that stressor. The species that may be exposed to stressors during each phase, and their likely response to exposure are based on the biological and/or ecological characteristics of each species. Any incidence where a stressor has more than a discountable risk of causing an adverse effect on any individual of the ESA- and/or UES-protected species will result in that stressor and those species being considered in the following biological opinion.

a. Exposure to elevated noise levels: While in flight between VAFB and the RMI, the missile and the payload would travel at velocities that cause sonic booms. High-intensity in-water noise would be created when large missile components, such as the missiles payload, impact the ocean's surface. The impact from the payload hitting the ground will also create a sound to land and water that could transfer to water causing impulsive sound sources. High intensity impulsive noises can adversely affect marine life. The USAF/USASMDC will also create sounds from vessels and human activity in and near water during placement and retrieval of sensors and other data collecting instruments, and retrieval of debris from the impact. Effects vary with the frequency, intensity, and duration of the sound source, and the body structure and hearing characteristics of the affected animal. Effects may include: non-auditory physical injury; temporary or permanent hearing damage expressed as temporary threshold shift (TTS) and permanent threshold shift (PTS) respectively; and behavioral impacts such as temporarily masked communications or acoustic environmental cues and modified behaviors.

Sound is a mechanical disturbance consisting of minute vibrations that travel through a medium, such as air, ground, or water, and is generally characterized by several variables. Frequency describes the sound's pitch and is measured in hertz (Hz) or cycles per second. Sound level describes the sound's loudness. Loudness can be measured and quantified in several ways, but the logarithmic decibel (dB) is the most commonly used unit of measure, and sound pressure level (SPL) is a common and convenient term used to describe intensity. Sound exposure level (SEL) is a term that is used to describe the amount of sound energy a receiver is exposed to over time. The dB scale is exponential. For example, 10 dB yields a sound level 10 times more intense than 1 dB, while a 20 dB level equates to 100 times more intense, and a 30 dB level is 1,000 times more intense. Sound levels are compared to a reference sound pressure, based on the medium, and the unit of measure is the micro-Pascal (µPa). In water, sound pressure is typically referenced to a baseline of 1 µPa (re 1 µPa), vice the 20 µPa baseline used for in-air measurements. As a rule of thumb, 26 dB must be added to an in-air measurement to convert to an appropriate in-water value for an identical acoustic source (Bradley and Stern 2008).

Transmission loss (attenuation of sound intensity over distance) varies according to several factors in water, such as water depth, bottom type, sea surface condition, salinity, and the amount of suspended solids in the water. Sound energy dissipates through mechanisms such as spreading, scattering, and absorption (Bradley and Stern 2008). Spreading refers to the apparent decrease in sound energy at any given point on the wave front because the sound energy is spread across an increasing area as the wave front radiates outward from the source. In unbounded homogenous water, sound spreads out spherically, losing as much as 7 dB with each doubling of range. Toward the other end of the spectrum, sound may expand cylindrically when vertically bounded such as by the surface and substrate, losing only about 3 dB with each doubling of range. Scattering refers to the sound energy that leaves the wave front when it "bounces" off of an irregular surface or particles in the water. Absorption refers to the energy that is lost through conversion to heat due to friction. Irregular substrates, rough surface waters, and particulates and bubbles in the water column increase scattering and absorption loss. Shallow nearshore water around Illeginni where the payload may impact, is vertically bounded by the seafloor and the surface, but is considered a poor environment for acoustic propagation because sound dissipates rapidly due to intense scattering and absorption. The unbounded deep open ocean waters where the motors would impact is considered a good acoustic environment where spherical spreading would predominate in the near field.

In the absence of location-specific transmission loss data, equations such as RL = SL – #Log(R) (RL = received level (dB); SL = source level (dB); # = spreading coefficient; and R = range in meters (m)) are used to estimate RL at a given range (isopleth). Spherical spreading loss is estimated with spreading coefficient of 20, while cylindrical spreading loss is estimated with spreading coefficient of 10. Spreading loss in near shore waters is typically somewhere between the two, with absorption and scattering increasing the loss. $RL = SL - 20_{Log}(R)$ was used here to estimate ranges in deep open ocean water, and $RL = SL - 15_{Log}(R)$ was used to estimate ranges in the lagoon and reef flat areas around Illeginni.

The sound pressures associated with non-auditory injury are very high and are generally associated with a shock wave that is generally not found in sounds that are created by a splashdown. The Navy identified a threshold for non-auditory injury based on gastrointestinal bursting at 237 dB re: 1 µPa (Finneran and Jenkins 2012). The sounds estimated from the splashdowns and sonic booms are clearly below those thresholds and are not likely to cause non-auditory injury to marine mammals, sea turtles, elasmobranchs, and large fishes.

Table 5. Estimated thresholds for TTS and behavioral changes for hearing groups. (Source: Finneran and Jenkins 2012; Popper et al. 2014; NMFS 2016)

Hearing Group	**TTS peak pressure threshold (SPL_{peak})**	**Weighted TTS onset threshold (SEL_{CUM})**	**Estimated threshold for behavioral changes**
Low-frequency cetaceans (humpback whale and other baleen whales)	213 dB	179 dB	Continuous = 120 dB_{RMS} Non-continuous = 160 dB (re: 1 µPa)
Mid-frequency cetaceans (dolphins, pilot whales and other toothed whales)	224 dB	178 dB	Continuous = 120 dB_{RMS} Non-continuous = 160 dB (re: 1 µPa)
High-frequency cetaceans (Kogia, true porpoises)	196 dB	153 dB	Continuous = 120 dB_{RMS} Non-continuous = 160 dB (re: 1 µPa)
Phocid pinnipeds (Hawaiian monk seals and other true seals)	212 dB	181 dB	Continuous = 120 dB_{RMS} Non-continuous = 160 dB (re: 1 µPa)
Sea turtles	224 dB	200 dB	160 dB
Sharks, rays, and fish	229 dB*	186 dB*	150 dB

* - SPL for lethal and sublethal damage to fish with swim bladders exposed to not specific to hearing.

The threshold for the onset of behavioral disturbance for all marine mammals from a single exposure to impulsive in-water sounds is ≥ 160 dB. Ongoing research suggests that these thresholds are both conservative and simplistic (detailed in Southall et al. 2007 and NOAA 2013). The draft revised thresholds for marine mammals uses two metrics: 1) exposure to peak sound pressure levels (SPL_{peak}); and 2) exposure to accumulated sound exposure levels (SEL_{cum}). The thresholds for single exposures to impulsive in-water sounds are listed in Table 5 for the onset of injury and temporary hearing impacts (NMFS 2016). Corals and mollusks can react to exposure to intense sound and could be affected by concussive forces if exposed to very intense sound sources such as an underwater detonation.

The major sources of noise during this project are: 1) airborne sonic boom, and 2) objects impact onto the water and onto land.

Sonic booms

A sonic boom is a thunder-like noise caused by the shock wave generated by an object moving at supersonic speed. As objects travel through the air, the air molecules are pushed aside with great force and this forms a shock wave much like a boat creates a bow wave (Kahle et al. 2019).

These types of man-made sounds can physically adversely affect animals exposed to them in several ways: 1) non-auditory injury (e.g., barotrauma), hearing loss (expressed as permanent or temporary threshold shift), and behavioral responses. They may also experience reduced hearing by masking (i.e. the presence of one sound affecting the perception of another sound). Of these physical effects, the one measurable effect that is most likely to occur at the lowest noise intensity, would be temporary threshold shift (TTS) or temporary hearing loss. The level of noise generated during the action was not loud enough to cause non-auditory injuries, and animals were not close enough or exposed long enough to lose their hearing permanently.

The missile travels faster than the speed of sound, generating a sonic boom, which follows the object. Each vehicle would fly at speeds sufficient to generate sonic booms from close to launch and extending to impact in Kwajalein Atoll. Sonic booms create elevated pressure levels both in the air and underwater. Models were used to estimate sound pressure levels for sonic booms for the MMIII flight tests (Moody 2004, USAF 2015), and those estimates are used for the Proposed Action. As each descending test RV approaches KMISS at hypersonic velocity, sonic booms are generated over a very broad area of the open ocean northeast of the atoll and continue southwesterly toward the point of impact (Figure 6) (USAF 2015). The sonic boom footprint narrows to just a few miles on either side of the flight path (USAF 2015). At the ocean surface, the sound pressure levels for the sonic booms would vary from 91 decibels (dB) in-air (reference value at 20 μPa) (117 re 1 μPa in-water) at the eastern-most range and increase to 150 dB in-air (176 re 1 μPa in-water) at the western-most range, close to the point of impact (USAF 2015). For those RVs that impact in the KMISS area, the sonic boom footprint would occur almost entirely over the open ocean (USAF 2015). The duration for sonic boom overpressures produced by the RVs ranges from 40 milliseconds where the boom is strongest to 124 milliseconds where it is weakest (Moody 2004, USAF 2015).

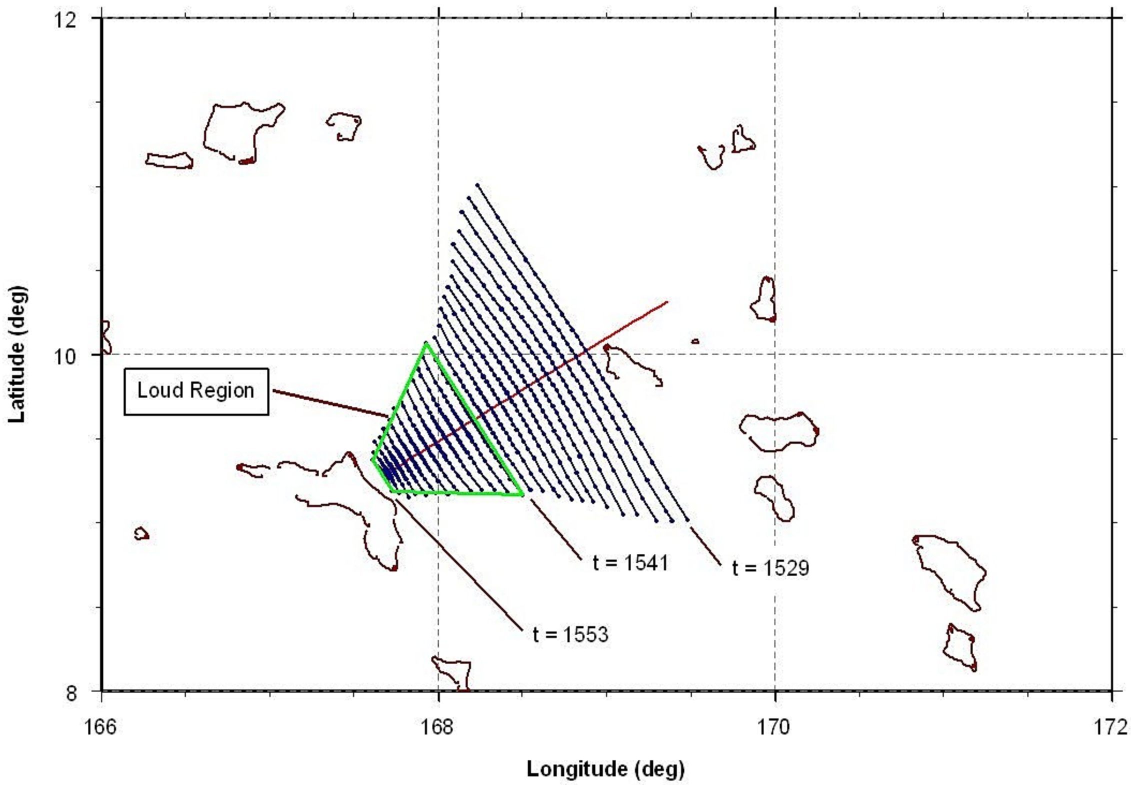

Figure 6. Representative Sonic Boom Footprint for an RV Impact at Kwajalein Atoll. (Source: USAF 2015)

At its loudest (176 dB in-water), the sonic boom at Kwajalein Atoll would not exceed permanent injury thresholds for consultation organisms and is below the TTS thresholds as well. Sonic booms are classified as impulsive and non-continuous sounds; therefore, for the purposes of this consultation we will be using the peak pressures to evaluate effects. Sounds in air are generally not loud enough to cause vibration and more specifically water molecules to move into each other and carry the sound further. Most of the airborne sound will be deflected, while the rest of the sound energy will be absorbed or refracted even further. The source sound level when it enters the surface is likely to be well below thresholds for injury of hearing loss. The sonic boom footprint for sounds above 160 dB re 1 µPa would likely cover a large area around the flight path; however, the sound would only last a fraction of a second (0.3 seconds). We believe that, at most, an exposed individual may experience temporary behavioral disturbance in the form of slight changes in swimming direction or speed, feeding, or socializing, that would have no measurable effect on the animal's fitness, and would return to normal within moments of the exposure. We expect exposure to sonic booms would have insignificant effects on any of the species considered in this consultation.

RV Impact Noise

Impact of the RV at the terminal end of the flight would result in elevated sound levels in-air and underwater. Sound pressure estimates for the MMIII RV impact in ocean waters were up to 240 dB re 1 µPa at 3.1 m (USAF 2015). The sound pressures would decrease with water depth and distance from the point of RV impact. Using a point source attenuation model with spherical spreading coefficient, sound pressures attenuate to 230 dB re 1 µPa at 10 m from

RV splashdown, 224 dB re 1 µPa at 20 m, and 202 dB re 1 µPa at 251 m. Sound pressure estimates are not available for high fidelity RV tests; however, the energy released during high fidelity tests is expected to be an order of magnitude less than that of a non-high fidelity test RV and the airburst would occur at some altitude above the surface (USAF 2015). Because the energy release would be less than for a non-high fidelity test RV and because much of sound intensity loss at the air-water interface, in-water sound pressures of high fidelity tests are expected to be less than for non-high fidelity test RV impacts.

For RV impacts in KMISS or the Vicinity of Illeginni Islet waters, sound pressure levels may peak up to 250 dB (1 µPa) at impact (which would last no more than a couple of seconds). Using a spherical spreading model for deep ocean waters (described in USAF 2015, NMFS 2015a, U.S. Navy 2019, NMFS 2019), the range to pressure effect thresholds from RV impact was calculated for UES consultation species groups (Table 6). This is a conservative approach given that it does not account for differential sound attenuation due to ocean conditions such as water depth, temperature, salinity, or stratification. The sound pressures from RV impact would exceed the PTS or non-auditory injury thresholds for consultation species but only very close to the impact point. Sound pressures would also exceed the TTS thresholds out 20 to 501 m from impact for cetaceans and sea turtles and up to 1,585 m for fish. RV impacts in the Vicinity of Illeginni Islet would in deep waters approximately 790 m southwest of Illeginni Islet and approximately 470 m from the outer edge of the fringing reef (NMFS 2015a). Therefore, maximum sound levels in reef habitats would be less than 196 dB re 1 µPa.

Table 6. Maximum Underwater Radial Distance to Elevated Sound Pressure Level Effect Thresholds for UES Consultation Species from GBSD RV Ocean Impact.

Species Group	**Effect Category**	**Threshold Criterion (re 1 μPa)**	**Radial Distance from RV Impact Point**	**Area around Impact Point, km^2 (mi^2)**
Low Frequency Cetaceans	PTS (non-lethal injury)	219 dBpeak	35 m (116 ft)	0.004 (0.002)
	TTS	213 dBpeak	71 m (232 ft)	0.016 (0.006)
Mid Frequency Cetaceans	PTS (non-lethal injury)	230 dBpeak	10 m (32 ft)	<0.001 (<0.001)
	TTS	224 dBpeak	20 m (65 ft)	0.001 (<0.001)
High Frequency Cetaceans	PTS (non-lethal injury)	202 dBpeak	251 m (824 ft)	0.198 (0.076)
	TTS	196 dBpeak	501 m (1,644 ft)	0.789 (0.305)
All Cetaceans	Behavioral Disturbance	160 dBpeak	32 km (20 mi)	3,142 (1,213)
Sea Turtles	Mortality/ Mortal Injury	237 dBpeak	4 m (15 ft)	<0.001 (<0.001)
	PTS (non-lethal injury)	230 dBpeak	10 m (32 ft)-	<0.001 (<0.001)
	TTS	224 dBpeak	20 m (65 ft)	0.001 (<0.001)
	Behavioral Disturbance	160 dBpeak	32 km (20 mi)	3,142 (1,213)
Fish	Mortality/ Mortal Injury	229 dBpeak	11 m (37 ft)-	<0.001 (<0.001)
	TTS	186 dB SELcum re 1 μPa^2-s	1,585 m (5,200 ft)	7.891 (3.046)
	Behavioral Disturbance	150 dBRMS	100 km (62 mi)	31,416 (12,129)

No data on UES listed cetaceans, sea turtle, and fish species densities are available in deep ocean waters of Kwajalein Atoll. However, if maximum density data for these species in other areas of the central Pacific Ocean (detailed in U.S. Navy 2019 and Hanser et al. 2017) are used, the number of expected injury, PTS, and TTS exposures for all species is substantially less than one. For example, around the Hawaiian Islands, the island stocks of pantropical spotted dolphins have maximum density estimates of 0.061 per square kilometer (km^2) (Hanser et al 2017), which would likely be on the very upper end of density for any cetacean species at Kwajalein Atoll. Using this density, the estimated number of exposures to PTS would be only 0.00002 individuals for each impact and only 0.00006 potential TTS exposures per impact. Using green sea turtle density estimates for offshore waters of Guam of 1 per 3.4 km^2 (U.S. Navy 2015b), there may be 0.00008 individual turtle exposures per impact to sounds above the PTS threshold, and 0.00029 exposures to sounds above the TTS threshold. These examples provide an estimate of the maximum number of exposures for

UES-consultation species in deep ocean waters of Kwajalein Atoll. Even if summed across the maximum of nine tests per year with up to three RVs per test, the number of individuals that might be exposed to pressures high enough to cause PTS or TTS is still estimated to be substantially less than one per year for these species and less than one over the proposed six years of the GBSD Test Program.

It is more likely that at some UES consultation species would be exposed to sound pressures above the behavioral disturbance thresholds and that some individuals may respond to the RV impact noise. However, NMFS concluded for the similar MMIII action that any effects of this single impulsive noise are expected to “be limited to a temporary behavioral modification in the form of slight changes in swimming direction or speed, feeding, or socializing, that would have no measurable effect on the animal's fitness, and would return to normal within moments of the exposure” (NMFS 2015a). Therefore, the probability of those individuals being within injury or TTS thresholds from RV impact sound pressures are discountable, and their effects of non-injurious sound generated from the GBSD testing on all listed sea turtles, marine mammals, and fish species are expected to be insignificant.

Acute and temporary acoustic exposures such as those associated with RV impact would be expected to cause, at most, temporary consequences for some of the more specialized marine invertebrates (U.S. Navy 2019). Temporary disruption of feeding or predator avoidance behaviors (Mooney et al. 2010) in some invertebrates (such as mollusks) are possible; however, being much less acoustically sensitive, any exposed corals or mollusks that may be on the outer reef edge are expected to be unaffected by payload impact noise. Giant clam larvae are not likely to be present in BOA and most likely will not be present in the KMISS, or will be in low numbers. Based on the above information, the payload impact noise associated with the GBSD testing would be insignificant on the ESA or UES-listed corals and mollusks listed in Table 2.

For payload impacts in the vicinity of Illeginni, the sea turtle and fish species listed in Table 1 that could occur along the outer edge of the fringing reef may be exposed to a brief pulse of sound from air or underground. Because the BOA and the KMISS are large open areas and the habitat for primarily pelagic and migratory sea turtle and fish species are as large, the probability of any individual of the pelagic species being in the action area during payload impacts is extremely low. The sound generated by vehicle impact will carry long distances and could be heard by the individuals of the species identified in table 1. Considering the large distribution of pelagic animals, the probability of those individuals being within injury or TTS thresholds are discountable, and their effects of non-injurious sound generated from the action are expected to be insignificant. At most, we expect that an exposed individual may experience a temporary behavioral disturbance, in the form of slight change in swimming direction or speed, feeding, or socializing, that would have no measurable effect on the animal’s fitness, and would return to normal within moments of the exposure. Therefore, the exposure is expected to have insignificant effects. Based on the best available information, exposure to payload impact noises is expected to have insignificant effects for all species considered in this consultation.

Shock Waves

RV impact would result in the RV impacting the ocean at high velocity either in the deep ocean waters of the KMISS or in the vicinity of Illeginni Islet and would generate underwater shock/sound waves. These in-water pressures were discussed above and are expected to have a larger area of potential effect than the contact area of the RV itself. RV impact in these deep ocean waters would not result in ground borne shock waves strong enough to injure corals or other any other species considered in this consultation.

However, for MMIII tests, shock waves resulting from payload impact on land were estimated to be strong enough to damage corals out as far as 37.5 m from the point of impact, and if impact occurred on the shoreline, shock waves would propagate into the submerged seafloor (USAF 2015). Even though shoreline impact is not planned or expected for GBSD testing, it is assumed that shock waves strong enough to damage corals might propagate up to 37.5 m into the marine environment, and larger pieces of debris could also crack or break parts of coral colonies or injure individual mollusks or fish. The adverse effects of shock waves associated with payload impact on Illeginni islet on coral species listed in Table 2 are further discussed in Section 6.

Exposure to intense ground borne shock waves could also injure soft tissues in mollusks, but the range of onset of significant injuries is likely much less than that estimated for corals (NMFS 2019). Since top shell snails are anchored to the substrate by their muscular foot, the muscular foot would somewhat isolate the snail’s shell and soft tissues from vibration and damage (NMFS 2019). Giant clams are anchored to the substrate; therefore, ground borne vibrations would travel through the clam’s shell and soft tissues (NMFS 2019). Since the range to potential shock wave effects for mollusks is less than for corals, shock waves are not likely to be strong enough to injure these species. Therefore, shock waves are expected to have insignificant effects to top shell snails and giant clams.

Humphead wrasses have the potential to be injured by the concussive shock waves; however, several factors make this highly unlikely. The shock waves would propagate primarily through the substrate and it can be assumed that little of the pressure intensity would be transferred to the water. Therefore, the range of onset of significant injuries to fish from shock waves is likely substantially less than for corals (NMFS 2019). In addition, humphead wrasses observed near Illeginni Islet have been observed beyond the reef crest around 91 m from the shoreline (NMFS 2019). As with elevated noise levels discussed previously, any realized effects of shock waves on nearshore fish, including the humphead wrasse, would likely be limited to temporary behavioral responses. Fish would be expected to return to normal behaviors within moments of exposure to shock wave pressures; therefore, shock waves produced from payload impact at Illeginni islet are expected to have insignificant effects on listed fish in the Action Area.

Sea turtles have the potential to be injured by shock waves produced during crater formation. Empirical evidence from previous tests corroborates predictions of the propagation of shock waves associated with impact were approximately 37.5 m through the adjacent reef from the point of impact on the shoreline (USAFGSC and USASMDC/ARSTRAT 2015). Although green and hawksbill sea turtles may occur around Illeginni Islet, they do so infrequently and in low numbers, and typically in waters closer to the reef edge, which is over 150 m (~500 ft) from shore, where they spend the majority of their time under water. Therefore, we consider it unlikely that either turtle species would be close enough to shore to be within the range of shock wave effects. In the unlikely event of a turtle being within the ejecta zone during the impact, at most, an exposed animal may experience temporary behavioral disturbance in the form of slight changes in swimming direction or speed, feeding, that would have no measurable effect on the animal's fitness, and would return to normal within moments of the exposure. Therefore, shock waves are expected to have insignificant effects to sea turtles.

Given that the target area on Illeginni Islet only includes terrestrial areas, sea turtles hauled out or nesting on land and their nests also have the potential to be injured from shock waves during crater formation. However, no sea turtle nesting activity has been recorded on Illeginni Islet in over 20 years. Therefore, it is considered extremely unlikely that sea turtles would be in terrestrial habitats on Illeginni Islet and it is discountable that sea turtles would be affected by shock waves. As an additional avoidance measure, Illeginni Islet would be surveyed for sea turtle nesting and haul-out activity prior to the flight tests as described in BMPs listed in Section 2.

No UES or ESA-listed marine mammals are expected to be close enough to be the area affected from potential direct contact. Therefore, there would be no effect of shock waves on cetaceans from land impacts.

Non-larval Fish, Corals, and Mollusks near Illeginni Islet. Non-larval forms of humphead wrasse, seven coral species, and three mollusk species (Table 2) 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 shock waves, which may affect and will likely adversely affect at least some of the consultation fish, coral and mollusk species on the adjacent reef. The analysis of these potential effects are analyzed below in Section 6.

Vessel Noise

The USAF/ USASMDC will use vessels of varying size to install and retrieve equipment in water to gather data and remove debris. Large vessels can create sounds ranging from 170-190 dB (re: 1 μPa). Smaller vessels like skiffs with outboards range from 150-170 dB. Vessels are generally moving and the sound sources are considered non-impulsive and mobile. Human activity in water during retrieval of instruments, debris, and ejecta are not louder than those sources. Air bubbles from SCUBA are among the higher noise sources considered, and were reported by Radford et al. (2005) with mean levels of 161 dB and mean peak levels of 177 dB at 1 m. We consider this source a non-impulsive, mobile, intermittent noise source. Because of the mobile nature of vessels and the intermittent nature of SCUBA bubbles, animals of all hearing groups are not likely to be exposed to the source long enough or continuously enough to experience TTS from vessels and SCUBA air bubbles. Furthermore, behavioral disturbances are likely brief because the mobile and temporary nature of the sources, and the noises will likely have an immeasurable effect on an individual's behavior during and after exposure.

<u>b. Direct contact from payload impacts</u>: The Proposed Action will result in impact of the payload on land at Illeginni Islet, within the vicinity of Illeginni Islet, and in the KMISS. The RVs payloads and 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. For the reasons discussed below, it is discountable that any of the species considered in this consultation would be hit by a RVs payload, or to be close enough to an impact site to be significantly affected by concussive forces. It is also discountable that any of the species

identified in Table 1 would be hit by payload or ejecta, or be significantly affected by concussive forces during the planned payload strikes on/within the vicinity of Illeginni Islet or in the KMISS. However, the payload strikes on Illeginni Islet may adversely affect the species identified in Table 2. Therefore, the potential effects of this stressor on those species are considered below in the effects of the action section (Section 6).

Direct Contact - Deep Ocean Water Impact

The GBSD RVs could potentially expose pelagic species in the vicinity of Illeginni Islet and KMISS by directly hitting them when the payload impacts into the ocean. Considering the size and speed of the components, a direct impact would likely kill or severely injure any animal it terminates on. Because the vicinity of Illeginni Islet and the KMISS are large open areas and the habitat for primarily pelagic and migratory shark, ray, and tuna species is as large, the probability of any individual of the pelagic species being in the action area during payload impact is extremely low. The likelihood of directly falling onto giant clam larvae is also extremely small, if present; however, the corals and mollusks listed in Table 2 are not expected to occur in deep ocean waters, and therefore would not be affected. If maximum density data for UES-consultation species in other areas of the central Pacific Ocean are used, the number individuals expected to be exposed to direct contact would be substantially less than one. Even if summed across the maximum of nine tests per year with up to three RVs per test and summed across the proposed six years of testing, the probability that any individual would be exposed to direct contact is still extremely low.

Therefore, the probability of falling missile payloads directly contacting listed marine mammals, sea turtles, fish, corals, and mollusks in deep ocean waters of the KMISS or in the vicinity of Illeginni Islet are discountable.

Direct Contact - Land Impact

For up to three total GBSD missile tests, an RV may impact on land at Illeginni Islet. Test RV components terminating at this test site would only directly impact terrestrial habitats but would have the potential to directly contact ESA and UES consultation species. No listed species would be at risk from crater formation; however, the potential exists for shoreline and nearshore reef-associated species to be at risk from debris being ejected from the crater and by shock waves radiating out from the point of impact as a result of the force from RV impact. Data from previous MMIII RV impact cratering and shock waves are used as estimates for the proposed GBSD testing. Craters from MMIII RV land impacts have been documented to be 6–9 m in diameter and 2–3 m deep (USAF 2015).

Crater formation would result in natural substrate (i.e., soil and coral rubble) being ejected around the rim of the crater upon impact. For MMIII testing, ejecta resulting from crater formations was estimated to extend no more than 60 to 91 m from the impact location (USAF 2015, U.S. Navy 2019). Based on observations from MMIII and other payload testing at Illeginni Islet, most of the RV materials and substrate ejecta would remain close to edge of the crater and the density of ejecta would be expected to decrease with distance from the impact point (USAF 2015).

A shoreline payload impact not expected or planned for the GBSD testing program, and most of the ejected debris would fall on land; however, a land RV impact near the shoreline could result in the dispersal of soil and rubble onto the shallow nearshore reef flat. For MMIII testing, the USAF estimated that the probability of a shallow water impact was between 0.1 and 0.2 (USAF 2015). Since the exact impact location and distribution of ejecta is unknown, these analyses assume a worst-case scenario of a shoreline RV impact where the ejected debris could enter the nearshore marine environment. Although the exact shape of the potential debris field is unknown, the seaward portion of such an area is conceptually illustrated below as a rough semi-circle on the lagoon and ocean sides of Illeginni Islet with a radius of 91 m (Figure 7). Based on the worst-case scenario, ejected debris has the potential to occur in a 13,008 square meter (m^2; 15,557 square yard [yd^2]) area.

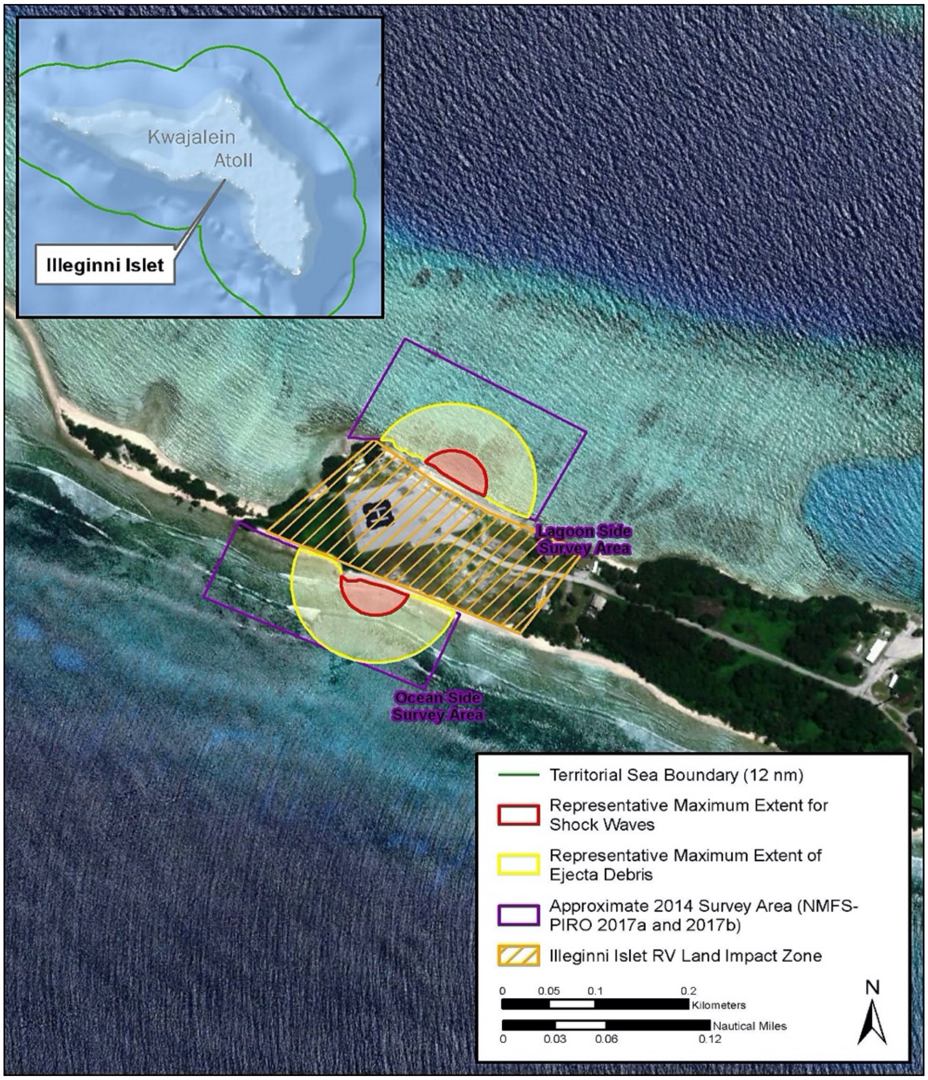

Figure 7. Representative Maximum Ejecta Debris Extent and Maximum Shock Wave Extent for a Shoreline RV Impact at Illeginni Islet (provided by USAF).

Furthermore, debris and ejecta from a land impact would be expected to fall within 91 m of the impact point. Of the species identified in Table 1, only green and hawksbill sea turtles may occur close enough to the potential impact site at Illeginni Islet to be affected by these stressors. Therefore we believe that, with the exception of green and hawksbill sea turtles, it is discountable that any of those species would be exposed to debris from the payload impact on Illeginni Islet.

Sea turtles have the potential to be injured if struck by debris ejected during crater formation. Empirical evidence from previous tests corroborates predictions of the propagation of shock waves associated with impact were approximately 37.5 m through the adjacent reef from the point of impact on the shoreline (USAFGSC and USASMDC/ARSTRAT 2015). Although green and hawksbill sea turtles may occur around Illeginni Islet, they do so infrequently and in low numbers, and typically in waters closer to the reef edge, which is over 150 m from shore, where they spend the majority of their time under water. Therefore, we consider it unlikely that either turtle species would be close enough to shore to be within this range and that any exposure to ejecta would be in the form of relatively slow moving material sinking to the bottom near the animal. In the unlikely event of a turtle being within the ejecta zone during the impact, at most, an exposed animal may experience temporary behavioral disturbance in the form of slight changes in swimming direction or speed, feeding, that would have no measurable effect on the animal's fitness, and would return to normal within moments of the exposure. Therefore, direct contact from ejecta is expected to have insignificant effects to sea turtles.

Given that the target area on Illeginni Islet only includes terrestrial areas, sea turtles hauled out or nesting on land and their nests also have the potential to be injured if struck by debris ejected during crater formation. However, no sea turtle nesting activity has been recorded on Illeginni Islet in over 20 years. Therefore, it is considered extremely unlikely that sea turtles would be in terrestrial habitats on Illeginni Islet and it is discountable that sea turtles would be affected by direct contact. As an additional avoidance measure, Illeginni Islet would be surveyed for sea turtle nesting and haul-out activity prior to the flight tests as described in BMPs listed in Section 2.

No UES or ESA-listed marine mammals are expected to be close enough to be the area affected from potential direct contact. Therefore, there would be no effect of direct contact on cetaceans from land impacts.

Non-larval Fish, Corals, and Mollusks near Illeginni Islet. Non-larval forms of humphead wrasse, seven coral species, and three mollusk species (Table 2) 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 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. The analysis of these potential effects are analyzed below in Section 6.

<u>c. Exposure to hazardous materials</u>: Impact of the GBSD RVs would have the potential to introduce propellants, battery acids, and heavy metals into the terrestrial or marine environment at the impact sites. The test RVs do not contain any fissile materials. However, based on the composition of MMIII RVs (detailed in Section 2), the test RVs would likely contain varying quantities of hazardous materials, potentially including batteries, explosives, asbestos, DU, and other heavy metals.

Immediately after payload impact in the KMISS or vicinity of Illeginni Islet, fragmentation of the RV would disperse any onboard hazardous materials such as Be and DU around the impact point. Be and DU fragments are highly insoluble (i.e., they dissolve extremely slowly), and dilution/mixing in the ocean water occurs much faster than dissolution of Be and

DU; therefore, their concentrations in seawater would likely be indistinguishable from natural background levels (USAF 2015). RV components would also sink relatively quickly to the ocean floor and would not be recovered in waters greater than 30 m deep. Although we would not expect materials such as Be and DU to dilute quickly, we would not expect these chemicals that leak at the oceans' surface and water column accumulating to levels expected to elicit a detectable response should a protected species be exposed to the material in the upper reaches of the water column. Furthermore, on the seafloor, the materials would leak or leach into the water and into bottom sediments. However, due to the amount of ocean water affected, this is highly immeasurable and is expected to be rapidly diluted by ocean currents.

Following an RV impact on land, fragmentation of the RV would also disperse any of the residual onboard hazardous materials around the impact point, however the majority of the RV fragments and materials would be expected to remain close to the impact point in terrestrial habitats. During post-test clean-up activities, attempts would be made to recover all visible man-made test debris. The impact crater and ejecta immediately surrounding the crater would be excavated and screened to remove RV debris. Pre-test preparatory and post-test cleanup activities may involve heavy equipment and ocean-going vessels, which have the potential to introduce fuels, hydraulic fluids, and battery acids to terrestrial habitats as well as marine habitats. Any accidental spills from support equipment operations would be contained and cleaned up. All waste materials would be transported to Kwajalein Islet for proper disposal in the United States. Only trace amounts of hazardous materials would be expected to remain in terrestrial areas after the test. Few, if any, hazardous materials would be expected to enter the nearshore marine environment and would be quickly diluted and dispersed by the large volume of ocean water and wave action.

Several avoidance, minimization, and mitigation measures would be in place as part of the Proposed Action to reduce the potential for adverse effects to listed species, including post-test soil and groundwater sampling for hazardous materials. Considering the planned cleanup of man-made materials, the very small quantities of hazardous materials expected to be introduce to terrestrial and marine habitats, and the dilution and mixing capabilities of the ocean and lagoon waters, materials released during RV impact would not be present in sufficient quantities or concentrations to adversely affect any of the UES or ESA-listed species listed in Tables 1 and 2 in the Action Area. Therefore, we believe that any effects from hazardous materials will be insignificant to all UES and ESA-consultation species in the area.

d. Disturbance from human activities and equipment operation: Both pre-flight preparations and post-flight cleanup activities may result in elevated levels of human activity in terrestrial and marine environments for several weeks.

At Illeginni Islet

During the several weeks of increased activity, several vessel round-trips are likely to occur. Helicopters would also be used to transport equipment and personnel to Illeginni Islet. Personnel and equipment would be used for preparation of the impact site including placement of cameras and other sensors in both terrestrial areas. Sensor rafts with onboard optical or acoustic sensors would be deployed by landing craft utility in the lagoon or ocean waters within approximately 792 m of the islet in waters no less than 3 m deep. Post-flight cleanup would involve recovery of all man-made test debris possible and would include personnel and equipment use in terrestrial habitats. Man-made debris would also be removed from the impact crater and filled with the surrounding substrate that was ejected. These post-test activities may involve the use of heavy equipment such as a backhoe or grader.

Post-test human activity in the marine areas near Illeginni Islet would likely only involve vessel traffic to and from Illeginni Islet as well as the collection of sensor rafts. Use of heavy equipment in the nearshore marine environment is not expected since shallow water and reef habitats would not be targeted. However, if test debris enters the nearshore marine environment, including the reef flat, test personnel may manually recover debris. Human activity in the nearshore marine environment would be limited to the area near the RV land impact where debris entered the water. In the event of an unexpected shoreline or reef-flat payload impact, several measures and procedures would be in place to guide post-test activities in order to avoid impacts to listed species. If divers are required to search for RV 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 RV debris that they would be looking for.

During planned testing activities, nearshore reef species including corals and mollusks would not be affected by human activity and equipment operation. Sessile organisms such as mollusks may temporarily close their shells or adhere more tightly to the substrate, also returning to normal behaviors within minutes of cessation of the activity. Corals are not expected to have any measurable reaction to short-term non-contact activities. While it has properly been assumed for listed vertebrate species that physical contact of equipment or humans with an individual constitutes an adverse effect due to high potential for harm or harassment, the same assumption does not hold for listed corals due to two key biological characteristics: 1) all corals are simple, sessile invertebrate animals that rely on their stinging nematocysts for defense, rather than predator avoidance via flight response, so whereas it is logical to assume that physical contact with a vertebrate individual results in stress that constitutes harm and/or harassment, the same does not apply to corals because they have no flight response; and 2) Most reef-building corals, including all the listed species, are colonial organisms, such that a single larva settles and develops into the primary polyp, which then multiplies into a colony of hundreds to thousands of genetically-identical polyps that are seamlessly connected through tissue and skeleton. Colony growth is achieved mainly through the addition of more polyps, and colony growth is indeterminate. The colony can continue to exist even if numerous polyps die, or if the colony is broken apart or otherwise damaged. The individual of these listed species is defined as the colony, not the polyp, in the final coral listing rule (79 FR 53852). Thus, affecting some polyps of a colony does not necessarily constitute harm to the individual.

Motile listed species are either not expected to be within this area (marine mammals and oceanic whitetip sharks), or they are expected to temporarily leave the area with no measurable effect on their fitness (green and hawksbill turtles, manta rays, oceanic white tip sharks, bigeye thresher sharks, and scalloped hammerhead sharks), and animals would be expected to return to normal behaviors within minutes of cessation of activity. Therefore, increased human activity and equipment operation is expected to have insignificant effects.

Since most human activities and equipment operation would take place on land, the only listed species with the potential to be affected by human activity and equipment operation on Illeginni Islet are hauled out or nesting sea turtles. Several mitigation measures would be in place to minimize the chance of affecting sea turtles, including sea turtle nest and activity searches of suitable habitat at Illeginni Islet leading up to the test. As discussed previously, no sea turtle nests or nesting activity have been observed on Illeginni in over 20 years. Sea turtle nest pits (unidentified species) were last found on the northern tip of Illeginni Islet in 1996. Therefore, it is considered discountable that any sea turtles or sea turtle nests would be affected by human activity and equipment operation in terrestrial habitats.

Vicinity of Illeginni Islet

In the Vicinity of Illeginni Islet, human activity would involve pre-test deployment and post-test recovery of sensory rafts as well a possible post-test RV recovery and cleanup. RVs typically strike waters in the Vicinity of Illeginni at a distance of approximately 792 m from shore. If necessary, searches for debris would be attempted to depths of 15–30 m (USAF 2015). A ship would be used for recovery and a remotely operated vehicle would be used to locate the debris field on the bottom before scuba divers would attempt to recover the debris manually (USAF 2015). 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 (USAF 2015).

KMISS

There are no pre-test or post-test cleanup or recovery activities required for GBSD flight tests in the KMISS portion of the Action Area. KMISS optical and electronic sensors and system support equipment are already in place on Gagan Islet and in the offshore ocean waters. For nominal missions, RVs that impact in deep ocean waters are not recovered.

<u>e. Collision with vessels</u>: The Proposed Action has the potential to increase ocean vessel traffic in the action area during both pre-flight preparations and post-flight activities for several weeks. Pre-test activities would include several vessel round-trips to and from Illeginni Islet or the vicinity of Illeginni Islet for personnel and equipment transport. Sensor rafts would also be deployed from a vessel near either of these impact sites. Post-test recovery efforts would also result in increased vessel traffic to Illeginni Islet or the Vicinity of Illeginni Islet. Vessels would be used to transport heavy equipment (such as backhoe or grader) and personnel for manual cleanup of debris, backfilling or any craters, instrument, and sensor raft recovery.

Sea turtles and cetaceans must surface to breathe air. They also rest or bask at the surface. Therefore, when at or near the surface, turtles and cetaceans are at risk of being struck by vessels or their propellers as the vessels transit. Corals could also be impacted if a vessel runs aground or drops anchors on the reef. Conversely, scalloped hammerhead sharks, bigeye thresher sharks, oceanic white tip sharks, manta rays, Pacific Bluefin tuna, and humphead wrasse respire with gills and as such do not need to surface to breathe and are only infrequently near the surface. They are also agile and capable of avoiding oncoming vessels.

The conservation measures that are part of this action include requirements for vessel operators to watch for and avoid marine protected species, including adjusting their speed based on animal density and visibility conditions. Additionally, no action-related anchoring is planned and vessel operators are well trained to avoid running aground, and no increased vessel traffic would occur for RV impacts in the KMISS area. Therefore, based on the best available information we consider the risk of collisions between project-related vessels and any of the consultation species identified in Tables 1 and 2 to be discountable.

f. Long-term addition of man-made objects to the ocean

This operation will scatter missile components in the KMISS, vicinity of Illeginni Islet, and likely throughout the Pacific Ocean. Man-made objects in the form of vessels, piles, pipelines, vehicles, and purposeful and unintended marine debris has entered all oceans for millennia and most of it is unquantified, especially things that do not float. Whales and sea turtles are most commonly observed entangled in fishing gear that floats on the surface, and recent surveys of sea turtles noted that they ingest plastics that float (high-density polyethylene, low-density polyethylene, and polypropylene) more commonly than plastic that does not float (Jung et al. 2018; White et al. 2018). This may suggest that man-made objects that float may pose more risk than objects that lay at the bottom of the ocean.

Almost all of the products in the missiles sink as soon as they impact the water and will likely remain on the bottom after the project is implemented. Although we do not know the specifics of the GBSD vehicle components and measurements, we expect complete combustion of propellant and liquid fuel.

All components of each missile are expected to sink immediately after entry into the water. If the payload does not detach and the missile is lost to the BOA, it would be expected to sink as well. We also understand that there is a paucity of data or observations of animals' interactions with debris at the bottom of the ocean, and that carcasses that do not float on the surface are almost never observed or captured for study. Nonetheless, based on empirical observation, the majority of entanglements are observed in gear that floats. Similarly, material that floats are observed more often in ingested non-organic material. The pelagic species are generally observed in the water column and are not considered bottom-dwelling, and they are less likely to be exposed to objects that are at the bottom than if they were mid-column or at the surface. We therefore expect the addition to debris from this proposed action to the bottom of the ocean to be insignificant.

4 STATUS OF THE SPECIES

This section presents biological or ecological information for the UES consultation species that the proposed action is likely to adversely affect. As stated above in Section 1, the USAF/USASMDC determined that the proposed action was likely to adversely affect the 11 marine UES consultation species listed in Table 2.

As described above in the introduction, the jeopardy analyses in this Opinion considers the risk of reducing appreciably the likelihood of survival and recovery of UES-protected marine species within USAKA. As such, subsections 4.1 through 4.11 provide species-specific descriptions of distribution and abundance, life history characteristics (especially those affecting vulnerability to the proposed action), threats to the species, and other relevant information as they pertain to these animals within USAKA. Factors affecting these species within the action area are described in more detail in the Environmental Baseline (Section 5).

4.1 *Pocillopora meandrina* (Cauliflower coral)

Pocillopora meandrina is listed as a species of "least concern" by the IUCN (IUCN 2015). The Center for Biological Diversity petitioned the NMFS to list the cauliflower coral in Hawaii as endangered or threatened under the ESA in March 2018 (CBD 2018). In September 2018, NMFS found that *P. meandrina* may warrant listing under the ESA (83 FR 47592 [September 20, 2018]). This species had been a candidate for listing under the ESA and was therefore protected under the UES; however, in 2020 NMFS found that the listing was not warranted and was removed as a candidate species. At this time, *P. meandrina* is still a UES consultation species.

Pocillopora meandrina is in the family Pocilloporidae. This hard coral species forms small upright bushes up to 30 cm in diameter that are cream, green, or pink in color (CBD 2018). Colonies form flattened branches that uniformly radiate out from the original growth point (CBD 2018). This species has a relatively fast growth rate with high recruitment; however, colonies may also be short lived due to recolonization by other coral species and high sensitivity to disturbance (CBD 2018).

4.1.1 Distribution and Abundance

Pocillopora meandrina is found throughout tropical and subtropical Indian and Pacific oceans in shallow reefs (CBD 2018). This range includes Hawaii, Johnston Atoll, American Samoa, the Marshall Islands, Micronesia, the Northern Mariana Islands, and Palau among other island groups (CBD 2018). *Pocillopora meandrina* occurs in shallow reef environments with high wave energy at depths of 1 to 27 m (CBD 2018). The abundance of this coral is still being determined through the status review process.

4.1.2 Life History Characteristics Affecting Vulnerability to Proposed Action

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

4.1.3 Threats to the Species

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

4.1.4 Conservation of the Species

Pocillopora meandrina has been retained as a consultation species under the UES.

4.2 *Acropora microclados* (Coral)

A. microclados is broadly distributed across the Indo-Pacific region. As a candidate species for listing under the ESA, *A. microclados* became a consultation species under UES section 3-4.5.1 (a), and retained that status, per the wishes of the RMI Government, after we determined that listing under the ESA was not warranted.

4.2.1 Distribution and Abundance

The reported range of *A. microclados* is from the Red Sea and northern Madagascar, the Chagos Archipelago in the central Indian Ocean, through the Indo-Pacific region, and eastward to the central Pacific Ocean out to Pitcairn Island. It ranges as far north as the Ryukyu Islands of Japan, and to the south down along the eastern and western coasts of Australia. *A. microclados* is reported as uncommon to common (Veron 2014). Within the area potentially impacted at Illeginni, *A. microclados* is estimated to be scattered across submerged hard pavement reef areas, mostly below the intertidal zone and very shallow water habitats, at a density of up to 0.08 colonies/m^2. It has been observed at Illeginni, all of the other USAKA islands, and at 34 of 35 sites within the mid-atoll corridor (NMFS 2014a). In a recent survey conducted at the Minuteman III impact area *A. microclados* was observed in the study area and the density estimates are slightly less than what was predicted (NMFS 2017a).

4.2.2 Life History Characteristics Affecting Vulnerability to Proposed Action

A. microclados is a scleractinian (stony) coral. Stony corals are sessile, colonial, marine invertebrates. A living colony consists of a thin layer of live tissue over-lying an accumulated calcium carbonate skeleton. The individual unit of a coral colony is called a polyp. Polyps are typically cylindrical in shape, with a central mouth that is surrounded by numerous small tentacles armed with stinging cells (nematocysts) that are used for prey capture and defense. Individual polyps secrete a cup-like skeleton (corallite) over the skeletons of its predecessors, and each polyp is connected to adjacent polyps by a thin layer of interconnecting tissue. Scleractinian corals act as plants during the day and as animals at night, or in some combination of the two. The soft tissue of stony corals harbor mutualistic intracellular symbiotic dinoflagellates called zooxanthellae, which are photosynthetic. Corals also feed by consuming prey that is captured by the nematocysts (Brainard et al. 2011).

A. microclados colonies are typically corymbose plates that are attached to hard substrate, with short, uniform, evenly spaced tapered branchlets. It occurs on upper reef slopes and subtidal reef edges at depths of 5 to 20 m. Like other corals, *A. microclados* feeds on tiny free-floating prey that is captured by the tentacles of the individual coral polyps that comprise the colony. *A. microclados* is a hermaphroditic spawner; releasing gametes of both sexes. It also reproduces through fragmentation, where broken pieces continue to grow to form new colonies (Brainard et al. 2011).

4.2.3 Threats to the Species

Current threats include: thermal stress, acidification, disease, predation, pollution, and exploitation. Increased exposure to thermal stress is a potential effect of anthropogenic climate change. Little specific information is available to describe the susceptibility of *A. microclados* to these threats. However, the genus *Acropora* is ranked as one of the more susceptible to bleaching, where the coral expels its zooxanthellae. The physiological stress and reduced nutrition from bleaching are likely to have synergistic effects of lowered fecundity and increased susceptibility to disease. Bleaching can also result in mortality of the affected colony (Brainard et al. 2011). Acidification experiments have demonstrated negative effects on *Acropora* calcification, productivity, and impaired fertilization, larval settlement, and zooxanthellae acquisition rates in juveniles (Brainard et al. 2011). The susceptibility and impacts of disease on *A. microclados* are not well understood, but subacute dark spots disease has been reported in this species, and its genus is considered moderate to highly susceptible to disease. The crown of thorns seastar (*Acanthaster planci*) and corallivorous snails preferentially prey on *Acropora spp.*, and the dead areas of the coral are rapidly overgrown by algae. Land-based toxins and nutrients are reported to have deleterious effects on *Acropora spp.* depending on the substance, concentration, and duration of exposure. The genus *Acropora* has been heavily involved in international trade, and *A. microclados* is likely included in this trade (Brainard et al. 2011). As described above, *A. microclados* is likely highly susceptible to effects attributed to anthropogenic climate change, and is likely being adversely affected by those effects on a global level.

4.2.4 Conservation of the Species

A. microclados is listed in CITES Appendix II, and has been retained as a consultation species under the UES.

4.3 *Acropora polystoma* (Coral)

A. polystoma is broadly distributed across the Indo-Pacific region. As a candidate species for listing under the ESA, *A. polystoma* became a consultation species under UES section 3-4.5.1 (a), and retained that status, per the wishes of the RMI Government, after we determined that listing under the ESA was not warranted.

4.3.1 Distribution and Abundance

The reported range of *A. polystoma* is from the Red Sea to central Africa and Madagascar, and the Chagos Archipelago in the central Indian Ocean, through the Indo-Pacific region, eastward to the Tuamotus in the southeastern Pacific Ocean. It ranges as far north as the south of Taiwan, through the South China Sea and the Philippines, and to the south down along the northern coast of Australia and the Coral Sea. *A. polystoma* is reported as uncommon to common (Veron 2014). Within the area potentially impacted at Illeginni, *A. polystoma* is estimated to be scattered across submerged hard pavement reef areas, mostly below the intertidal zone and very shallow water habitats, at a density of up to 0.08 colonies/m^2. It has been observed at Illeginni, all of the other USAKA islands, and at 34 of 35 sites within the mid-atoll corridor (NMFS 2014a). In a recent survey conducted at the Minuteman III impact area *A. polystoma* was observed in the study area and the density estimates are slightly less than what was predicted (NMFS 2017a).

4.3.2 Life History Characteristics Affecting Vulnerability to Proposed Action

A. polystoma is a stony coral. *A. polystoma* colonies are typically clumps or corymbose plates that are attached to hard substrate, with tapered branches of similar length. It occurs in highly active intertidal to shallow subtidal reef tops and edges with strong wave action and/or high currents, at depths down to about 10 m. *A. polystoma* is a hermaphroditic spawner; releasing gametes of both sexes. It also reproduces through fragmentation, where broken pieces continue to grow to form new colonies (Brainard et al. 2011).

4.3.3 Threats to the Species

Current threats include: thermal stress, acidification, disease, predation, pollution, and exploitation. Increased exposure to thermal stress is occurring as part of the rising ocean temperatures being caused by anthropogenic climate change. Little specific information is available to describe the susceptibility of *A. polystoma* to these threats. However, the genus *Acropora* is ranked as one of the most severely susceptible to bleaching, where the coral expels its zooxanthellae. The physiological stress and reduced nutrition from bleaching are likely to have synergistic effects of lowered fecundity and increased susceptibility to disease. Bleaching can also result in mortality of the affected colony (Brainard et al. 2011). Acidification experiments have demonstrated negative effects on *Acropora* calcification, productivity, and impaired fertilization, larval settlement, and zooxanthellae acquisition rates in juveniles (Anthony et al. 2008). The genus *Acropora* is considered moderate to highly susceptible to disease, and *A. polystoma* has been reported to experience severe white-band/white plague disease. The crown of thorns seastar (*Acanthaster planci*) and corallivorous snails preferentially prey on *Acropora spp.*, and the dead areas of the coral are rapidly overgrown by algae. Land-based toxins and nutrients are reported to have deleterious effects on *Acropora spp.* depending on the substance, concentration, and duration of exposure. The genus *Acropora* has been heavily involved in international trade, and *A. polystoma* is likely included in this trade (Brainard et al. 2011). As described above, *A. polystoma* is likely highly susceptible to effects attributed to anthropogenic climate change, and is likely being adversely affected by those effects across its range.

4.3.4 Conservation of the Species

A. polystoma is listed in CITES Appendix II, and has been retained as a consultation species under the UES.

4.4 *Cyphastrea agassizi* (Coral)

C. agassizi is found primarily in the Indo-Pacific. As a candidate species for listing under the ESA, *C. agassizi* became a consultation species under UES section 3-4.5.1 (a), and retained that status, per the wishes of the RMI Government, after we determined that listing under the ESA was not warranted.

4.4.1 Distribution and Abundance

The reported range of *C. agassizi* is from Indonesia to the Hawaiian Islands in the central Pacific Ocean, and from southern Japan and the Northern Mariana Islands, south to Northeastern Australia. *C. agassizi* is reported as uncommon (Veron 2014). Within the area potentially impacted at Illeginni, *C. agassizi* is estimated to be scattered across submerged hard pavement reef areas, mostly below the intertidal zone and very shallow water habitats, at a density of up to 0.08 colonies/m^2. It has been observed at Illeginni, at six more of the 11 USAKA islands, and at 14 of 35 sites within the mid-atoll corridor (NMFS 2014a). In a recent survey conducted at the Minuteman III impact area *C. agassizi* was observed in the study area and the density estimates are slightly less than what was predicted (NMFS 2017a).

4.4.2 Life History Characteristics Affecting Vulnerability to Proposed Action

C. agassizi is stony coral. *C. agassizi* typically forms deeply grooved massive colonies attached to hard substrate. It occurs in shallow reef environments of back- and fore-slopes, lagoons and outer reef channels at depths of about 2 to 20 m. Like other corals, *C. agassizi* feeds on tiny free-floating prey that is captured by the tentacles of the individual coral polyps that comprise the colony. The reproductive characteristics of *C. agassizi* are undetermined, but its congeners include a mix of hermaphroditic spawners and brooders (Brainard et al. 2011).

4.4.3 Threats to the Species

Current threats include: thermal stress, acidification, disease, predation, pollution, and exploitation. Increased exposure to thermal stress is a potential effect of anthropogenic climate change. *Cyphastrea* are considered generally resistant to bleaching, but elevated temperatures may still cause mortality within this genus (Brainard et al. 2011). The effects of increased ocean acidity are unknown for this genus, but in general, increased ocean acidity is thought to adversely affect fertilization, larval settlement, and zooxanthellae acquisition rates for many corals. It also can induce bleaching more so than thermal stress, and tends to decrease growth and calcification rates. The specific susceptibility and impacts of disease on *C. agassizi* are not known, but some of its congeners have been infected with various “band” diseases. As such, it appears that *C. agassizi* is susceptible (Brainard et al. 2011). The susceptibility of *C. agassizi* to predation is unknown. The effects of land-based pollution on *C. agassizi* are largely unknown, but it may pose significant threats at local scales. This coral light to moderately exploited in trade at the genus level (Brainard et al. 2011). As described above, the genus *Cyphastrea* is considered generally resistant to bleaching, but mortality due to elevated temperatures, which may be attributable to anthropogenic climate change, may still occur. As such, this species may be currently adversely affected by those effects on a global level.

4.4.4 Conservation of the Species

C. agassizi is listed in CITES Appendix II, and has been retained as a consultation species under the UES.

4.5 *Heliopora coerulea* (Coral)

H. coerulea is a very broadly distributed Indo-Pacific coral. It is considered the oldest living coral species. *H. coerulea* became a consultation species under UES section 3-4.5.1 (a), and retained that status, per the wishes of the RMI Government, after we determined that listing under the ESA was not warranted.

4.5.1 Distribution and Abundance

The reported range of *H. coerulea* is from southern east Africa to the Red Sea, across the Indian Ocean to American Samoa in central Pacific Ocean, and from Japan, south to Australia (Brainard et al. 2011). Colonies of *H. coerulea* are often patchy in their distribution, but can dominate large areas. Within the area potentially impacted at Illeginni, *H. coerulea* is estimated to be scattered across submerged hard pavement reef areas, including intertidal and/or inshore rocky areas, at a density of up to 0.53 colonies/m^2. It has been observed at Illeginni, at all of the other USAKA islands, and at 32 of 35 sites within the mid-atoll corridor (NMFS 2014a). In a recent survey conducted at the Minuteman III impact area *H. coerulea* was observed in the study area and the density estimates are slightly less than what was predicted (NMFS 2017a).

4.5.2 Life History Characteristics Affecting Vulnerability to Proposed Action

H. coerulea is a non-scleractinian stony coral. Stony corals are sessile, colonial, marine invertebrates. Unlike the calcium carbonate skeleton of scleractinian corals, the skeleton of *H. coerulea* consists of aragonite, and it is blue instead of white. As with scleractinian corals, the individual unit of a coral colony is called a polyp, which is typically cylindrical in shape, with a central mouth that is surrounded by numerous small tentacles armed with stinging cells (nematocysts) that are used for prey capture and defense, but instead of living in "cups on the surface of the coral, *H. coerulea* polyps live in tubes within the skeleton. Each polyp is connected to adjacent polyps by a thin layer of interconnecting tissue called the coenenchyme. As with other corals, *H. coerulea* acts as a plant during the day and as an animal at night, or in some combination of the two. The soft tissue harbors mutualistic intracellular symbiotic dinoflagellates called zooxanthellae, which are photosynthetic. Corals also feed by consuming prey that is captured by the nematocysts (Brainard et al. 2011).

H. coerulea is a massive coral that typically forms castellate blades. It occurs in water depths from the intertidal zone down to about 60 m. It is most abundant from the shallow reef crest down to forereef slopes at 10 m, but is still common down to 20 m. Like other corals, *H. coerulea* feeds on tiny free-floating prey that is captured by the tentacles of the individual coral polyps that comprise the colony. *H. coerulea* colonies have separate sexes. Fertilization and early development of eggs begins internally, but the planula larvae are brooded externally under the polyp tentacles. Larvae are considered benthic, as they normally distribute themselves by crawling away vice drifting in the plankton (Brainard et al. 2011).

4.5.3 Threats to the Species

Brainard et al. (2011) suggest that *H. coerulea* is a hardy species. They report that it is one of the most resistant corals to the effects of thermal stress and bleaching, and although there is no specific research to address the effects of acidification on this species, it seems to have survived the rapid acidification of the oceans during the Paleocene-Eocene Thermal Maximum acidification. They also report that disease does not appear to pose a substantial threat, and that adult colonies are avoided by most predators of coral. However, the externally brooded larvae are heavily preyed upon by several species of butterflyfish. Although *H. coerulea* tends to prefer clear water with low rates of sedimentation, Brainard et al. (2011) report that sediment appears to pose no significant threat to the species. Land-based sources of pollution may pose significant threats at local scales. Collection and trade appear to be the biggest threat to this species. *H. coerulea* has been reported as one of the top 10 species involved in international trade. Its morphology and natural color make it highly desirable (Brainard et al. 2011). As described above, *H. coerulea* does not appear to be particularly susceptible to effects attributed to anthropogenic climate change, but it is likely being adversely affected by international trade.

4.5.4 Conservation of the Species

H. coerulea is listed in CITES Appendix II, and has been retained as a consultation species under the UES.

4.6 *Pavona venosa* (Coral)

P. venosa is a broadly distributed Indo-Pacific. It became a consultation species under UES section 3-4.5.1 (a), and retained that status, per the wishes of the RMI Government, after we determined that listing under the ESA was not warranted.

4.6.1 Distribution and Abundance

The reported range of *P. venosa* extends down the eastern shore of the Saudi Arabian, into the Red Sea, down to central Africa and Madagascar, across the Indian Ocean to include the Chagos Archipelago and Sri Lanka, through the Indo-Pacific region, eastward to the Tuamotus in the southeastern Pacific Ocean. It ranges as far north as the Ryukyu Islands, through the South China Sea and the Philippines, and to the south down along the east and west coasts of Australia and the Coral Sea. *P. venosa* has been reported as common. Within the area potentially impacted at Illeginni, *P. venosa* is estimated to be scattered across submerged hard pavement reef areas, mostly below the intertidal zone and very shallow water habitats, at a density of up to 0.08 colonies/m^2. It has been observed at Illeginni, all of the other USAKA islands, and at 16 of 35 sites within the mid-atoll corridor (NMFS 2014a). In a recent survey conducted at the Minuteman III impact area *P. venosa* was observed in the study area and the density estimates are slightly less than what was predicted (NMFS 2017a).

4.6.2 Life History Characteristics Affecting Vulnerability to Proposed Action

P. venosa is a stony coral. *P. venosa* typically forms massive to encrusting colonies attached to hard substrate. It occurs in shallow reef environments at depths of about 2 to 20 m. The reproductive characteristics of *P. venosa* are unknown, but six of its congeners are gonochoric (separate sexes) spawners; releasing gametes of both sexes that become fertilized in the water (Brainard et al. 2011).

4.6.3 Threats to the Species

Current threats include: thermal stress, acidification, disease, predation, pollution, and exploitation. Increased exposure to thermal stress is occurring as part of the rising ocean temperatures being caused by anthropogenic climate change. *P. venosa* has moderate to high susceptibility to thermal stress induced “bleaching” where the coral expels its zooxanthellae. The physiological stress and reduced nutrition from bleaching are likely to have synergistic effects of lowered fecundity and increased susceptibility to disease. Bleaching can also result in mortality of the affected colony (Brainard et al. 2011). In general, increased ocean acidity is thought to adversely affect fertilization, larval settlement, and zooxanthellae acquisition rates for many corals. It can increase the susceptibility to thermal stress, and tends to decrease growth and calcification rates (Anthony et al. 2008). No studies have examined the direct impacts of ocean acidification on *P. venosa*, but some evidence suggests that the genus *Pavona* has some degree of tolerance to acidification (Brainard et al. 2011). The specific susceptibility and impacts of disease on *P. venosa* are not known, but susceptibility is considered to be low (Brainard et al. 2011). There are a medium number of reports of acuter white disease for the genus *Pavona*. The susceptibility of *P. venosa* to predation is considered to be low, but there is no specific information. Members of the genus *Pavona* have varied susceptibility to predation by the crown of thorns seastar (*Acanthaster planci*). There is no specific information about the effects of land-based pollution on *P. venosa*, but it may pose significant threats at local scales. International trade includes the genus *Pavona*, but at relatively low levels (Brainard et al. 2011). As described above, *P. venosa* is susceptible to effects of thermal stress, which may be attributable to anthropogenic climate change. As such, this species is likely being adversely affected by those effects across its range.

4.6.4 Conservation of the Species

P. venosa is listed in CITES Appendix II, and has been retained as a consultation species under the UES.

4.7 *Turbinaria reniformis* (Coral)

T. reniformis is very broadly distributed across the Indo-Pacific region. *T. reniformis* became a consultation species under UES section 3-4.5.1 (a), and retained that status, per the wishes of the RMI Government, after we determined that listing under the ESA was not warranted.

4.7.1 Distribution and Abundance

The reported range of *T. reniformis* includes the Persian Gulf, the Red Sea, and most of the Indian Ocean basin, through the Indo-Pacific region, and eastward to the central Pacific Ocean out to Samoa and the Cook Islands. It ranges as far north as central Japan, down through the Philippines, around New Guinea, and down along the east and west coasts of Australia, and also down the Marianas, the Marshalls, and east to the Line Islands. It has been reported as common (Veron 2014). Within the area potentially impacted at Illeginni, *T. reniformis* is estimated to occur in small aggregations on submerged hard pavement reef areas, at a density of up to 0.16 colonies/m^2. It has been observed at Illeginni, at five more of the 11 USAKA islands, and at nine of 35 sites within the mid-atoll corridor (NMFS 2014a). In a recent survey conducted at the Minuteman III impact area *T. reniformis* was observed in the study area and the density estimates are slightly less than what was predicted (NMFS 2017a).

4.7.2 Life History Characteristics Affecting Vulnerability to Proposed Action

T. reniformis is a stony coral. *T. reniformis* colonies are attached to hard substrate and typically form large lettuce-like assemblages of plates. The plates tend to be very convoluted in shallow active water, whereas they are broad and flat in deeper calmer waters. It has been reported from the surface down to over 0 to 40 m, commonly on forereef slopes at 10 m and deeper, but it prefers turbid shallow protected waters where it forms massive and extensive stands. Like other corals, *T. reniformis* feeds on tiny free-floating prey that is captured by the tentacles of the individual coral polyps that comprise the colony. *T. reniformis* is a gonochoric (separate sexes) spawner; releasing gametes of one sex or the other that become fertilized in the water (Brainard et al. 2011).

4.7.3 Threats to the Species

Current threats include: thermal stress, acidification, disease, predation, pollution, and exploitation. Increased exposure to thermal stress is a potential effect of anthropogenic climate change. Susceptibility of *Turbinaria spp*. to thermal stress induced bleaching (where the coral expels its zooxanthellae) varies regionally, and among species, but ranges between low to moderate. The physiological stress and reduced nutrition from bleaching may have synergistic effects of lowered fecundity and increased susceptibility to disease. Bleaching can also result in mortality of the affected colony. However, *T. reniformis* has shown the potential to reduce bleaching impacts through increased heterotrophic feeding rates (Brainard et al. 2011). The susceptibility of *T. reniformis* to acidification appears to be lower than that of other genera of scleractinian corals tested. However, in most corals studied, acidification impaired growth, as well as impaired fertilization, larval settlement, and zooxanthellae acquisition rates in juveniles for some species (Brainard et al. 2011). Susceptibility and impacts of disease on *T. reniformis* are not known, but both white syndrome disease and black lesions have affected members of this genus. Adult colonies of *Turbinaria spp.* are rarely eaten by the crown of thorns seastar (*Acanthaster planci*), but the gastropod nudibranch (*Phestilla sibogae*) both feeds upon, and infects *Turbinaria spp.* with disease. *T. reniformis* appears to tolerate high turbidity and sedimentation, as well as low-salinity events, but land-based toxins and nutrients may have deleterious effects on a regional scale, depending on the substance, concentration, and duration of exposure. The genus *Turbinaria* has been heavily exploited in international trade, and *T. reniformis* is likely included in this trade (Brainard et al. 2011). As described above, *T. reniformis* may be susceptible to some effects attributed to anthropogenic climate change, and as such could be currently adversely affected by those effects on a global level.

4.7.4 Conservation of the Species

T. reniformis is listed in CITES Appendix II, and has been retained as a consultation species under the UES.

4.8 *Tectus niloticus* (Top Shell Snail)

The top shell snail is also sometime referred to as *Trochus niloticus*. It is a broadly distributed marine gastropod, and is a consultation species under UES section 3-4.5.1 (a).

4.8.1 Distribution and Abundance

The top shell snail is distributed in sub-tropical to tropical waters of the Indo-Pacific region. They are indigenous to Yap, Palau, and Helen Reef in Micronesia, but have been introduced to nearly every island group across the Indo-Pacific region (Smith 1987). Larvae recruit to shallow intertidal zones, typically along exposed (seaward) shores. Individuals migrate into deeper water as they grow (Heslinga et al. 1984) with maximum reported depth being 24 m (Smith 1987). Data are insufficient to determine current population levels and trends across its range, including in the RMI. Within the area potentially impacted at Illeginni, the top shell snail is estimated to be scattered across submerged hard pavement reef areas, including intertidal and/or inshore rocky areas, at a density of up to 0.09 individuals/m^2. It has been observed at Illeginni, at all of the other USAKA islands, and at 12 of 35 sites within the mid-atoll corridor (NMFS 2014a).

4.8.2 Life History Characteristics Affecting Vulnerability to Proposed Action

The top shell is a nocturnal, herbivorous, marine gastropod mollusk. It is normally found on the reef surface in the intertidal and subtidal zones. The life span is between 15 and 20 years, with sexual maturity occurring at about 2 years. It is a hardy species that is commonly relocated between island groups with high success. Dobson (2001), reports that top shell snails can survive out of the water for up to 36 hours when kept cool and damp. After being relocated on a new reef area and left undisturbed for a brief period, top shell snails typically resume normal behaviors with no measurable effects assuming the relocation site supports adequate forage and shelter.

4.8.3 Threats to the Species

The top shell is highly susceptible to over-exploitation. It is an edible species whose shells are also commercially important in the mother of pearl button industry (Heslinga et al. 1984). They are slow moving and are easily spotted by reef-walkers and snorkelers. Unregulated or poorly regulated harvesting has led to their depletion across their range. Although top shell snails are probably beginning to be affected by impacts associated with anthropogenic climate change (described in more detail in the Environmental Baseline section below), no significant climate change-related impacts to its populations have been observed to date.

4.8.4 Conservation of the Species

The top shell is afforded protection at USAKA as a consultation species under the UES (USAKA 2014).

4.9 *Hippopus hippopus* (giant clam)

H. hippopus is broadly distributed across the Indo-Pacific region. It is a candidate species for listing under the ESA, *H. hippopus* became a consultation species under UES section 3-4.5.1 (a).

4.9.1 Distribution and Abundance

H. hippopus are reported to be found in the eastern Indian Ocean at Myanmar and east to the Fiji and Tonga Islands, in the north as far as southern Japan and then south to the Great Barrier Reef, New Caledonia and Western Australia. Within the area potentially impacted at Illeginni, *H. hippopus* was found throughout the lagoon area but was rare on the ocean side in a recent survey conducted at the impact area. It has been observed at Illeginni, and at eight more of the 11 USAKA islands, and at nine of 35 sites within the mid-atoll corridor (NMFS 2017b).

4.9.2 Life History Characteristics Affecting Vulnerability to Proposed Action

H. hippopus is a giant clam which is markedly stenothermal (i.e., they are able to tolerate only a small range of temperature) and thus restricted to warm waters. Giant clams are typically found living on sand or attached to coral rock and rubble by byssal threads (Soo and Todd 2014), but they can be found in a wide variety of habitats, including live coral, dead coral rubble, boulders, sandy substrates, seagrass beds, macroalgae zones, etc. (Gilbert et al. 2006; Hernawan 2010).

The exact lifespan of tridacnines has not been determined; although it is estimated to vary widely between 8 to several hundred years (Soo and Todd 2014). Little information exists on the size at maturity for giant clams, but size and age at maturity vary by species and geographical location (Ellis 1997). In general, giant clams appear to have relatively late sexual maturity, a sessile, exposed adult phase and broadcast spawning reproductive strategy, all of which can make giant clams vulnerable to depletion and exploitation (Neo *et al.* 2015). All giant clam species are classified as protandrous functional hermaphrodites, meaning they mature first as males and develop later to function as both male and female (Chambers 2007); but otherwise, giant clams follow the typical bivalve mollusk life cycle. At around 5 to 7 years of age (Kinch and

Teitelbaum 2010), giant clams reproduce via broadcast spawning, in which several million sperm and eggs are released into the water column where fertilization takes place. Giant clam spawning can be seasonal; for example, in the Central Pacific, giant clams can spawn year round but are likely to have better gonad maturation around the new or full moon (Kinch and Teitelbaum 2010). In the Southern Pacific, giant clam spawning patterns are seasonal and clams are likely to spawn in spring and throughout the austral summer months (Kinch and Teitelbaum 2010). Once fertilized, the eggs hatch into free-swimming trochophore larvae for around 8 to 15 days (according to the species and location) before settling on the substrate (Soo and Todd 2014; Kinch and Teitelbaum 2010). During the pediveliger larvae stage (the stage when the larvae is able to crawl using its foot), the larvae crawl on the substrate in search of suitable sites for settlement and metamorphose into early juveniles (or spats) within 2 weeks of spawning (Soo and Todd 2014).

According to Munro (1993), giant clams are facultative planktotrophs, in that they are essentially planktotrophic (i.e., they feed on plankton) but they can acquire all of the nutrition required for maintenance from their symbiotic algae, *Symbiodinium*.

4.9.3 Threats to the Species

Current threats include: thermal stress, acidification, disease, pollution, and exploitation. The harvest of giant clams is for both subsistence purposes (e.g., giant clam adductor, gonad, muscle, and mantle tissues are all used for food products and local consumption), as well as commercial purposes for global international trade (e.g., giant clam shells are used for a number of items, including jewelry, ornaments, soap dishes). The extent of each of these threats is largely unknown. Blidberg et al. (2000) studied the effect of increasing water temperature on *T. gigas, T. derasa,* and *H. hippopus* at a laboratory in the Philippines. *H. hippopus* experienced increased respiration and production of oxygen in elevated temperatures and was therefore more sensitive to higher temperature than the two other species tested. After 24 hours at ambient temperature plus 3°C, however, no bleaching was observed for any of the species. The susceptibility and impacts of disease on *H hippopus* are not known, but incidences of mortality from rickettsiales-like organisms in cultured clams in the western Pacific, one in the Philippines and one in Kosrae have been documented (Norton et al. 1993).

4.9.4 Conservation of the Species

H hippopus is listed in CITES Appendix II, is an ESA candidate species and is therefore a consultation species under the UES.

4.10 *Tridacna squamosa* (giant clam)

T. squamosa is broadly distributed across the Indo-Pacific region. It is a candidate species for listing under the ESA, therefore *T. squamosa* is a consultation species under UES section 3-4.5.1 (a).

4.10.1 Distribution and Abundance

T. squamosa has a widespread distribution across the Indo-Pacific. Its range extends from the Red Sea and East African coast across the Indo-Pacific to the Pitcairn Islands. It has also been introduced in Hawaii (CITES 2004). The species' range also extends north to southern Japan, and south to Australia and the Great Barrier Reef (bin Othman *et al*. 2010). This range description reflects the recent range extension of *T. squamosa* to French Polynesia as a result of observations by Gilbert et al. (2007). Within the area potentially impacted at Illeginni, *T. squamosa* was observed in the lagoon area but not on the ocean side in a recent survey conducted at the impact area. It has been observed at Illeginni, at five more of the 11 USAKA islands, and at 24 of 35 sites within the mid-atoll corridor (NMFS 2017b).

4.10.2 Life History Characteristics Affecting Vulnerability to Proposed Action

T. squamosa is a giant clam which are markedly stenothermal (i.e., they are able to tolerate only a small range of temperature) and thus restricted to warm waters. *T. squamosa* is usually recorded on reefs or sand; it is found attached by its byssus to the surface of coral reefs, usually in moderately protected localities such as reef moats in littoral and shallow water to a depth of 20 m (Kinch and Teitelbaum 2010). This species tends to prefer fairly sheltered lagoon environments next to high islands; however, *T. squamosa* appears to be excluded by *T. maxima* in the closed atoll lagoons of Polynesia (Munro 1992). Neo et al. (2009) found that *T. squamosa* larvae, like many reef invertebrates, prefer substrate with crustose coralline algae. *Tridacna squamosa* is also commonly found amongst branching corals (staghorn, *Acropora* spp.; CITES 2004).

The exact lifespan of tridacnines has not been determined; although it is estimated to vary widely between 8 to several hundred years (Soo and Todd 2014). Little information exists on the size at maturity for giant clams, but size and age at maturity vary by species and geographical location (Ellis 1997). In general, giant clams appear to have relatively late sexual maturity, a sessile, exposed adult phase and broadcast spawning reproductive strategy, all of which can make giant clams vulnerable to depletion and exploitation (Neo *et al.* 2015). All giant clam species are classified as protandrous functional hermaphrodites, meaning they mature first as males and develop later to function as both male and female (Chambers 2007); but otherwise, giant clams follow the typical bivalve mollusk life cycle. *T. squamosa* reaches sexual maturity at sizes of 6 to 16 cm, which equates to a first year of maturity at approximately four years old (CITES 2004). Giant clam spawning can be seasonal; for example, in the Central Pacific, giant clams can spawn year round but are likely to have better gonad maturation around the new or full moon (Kinch and Teitelbaum 2010). In the Southern Pacific, giant clam spawning patterns are seasonal and clams are likely to spawn in spring and throughout the austral summer months (Kinch and Teitelbaum 2010). Once fertilized, the eggs hatch into free-swimming trochophore larvae for around 8 to 15 days (according to the species and location) before settling on the substrate (Soo and Todd 2014; Kinch and Teitelbaum 2010). During the pediveliger larvae stage (the stage when the larvae is able to crawl using its foot), the larvae crawl on the substrate in search of suitable sites for settlement and metamorphose into early juveniles (or spats) within two weeks of spawning (Soo and Todd 2014).

According to Munro (1993), giant clams are facultative planktotrophs, in that they are essentially planktotrophic (i.e., they feed on plankton) but they can acquire all of the nutrition required for maintenance from their symbiotic algae, *Symbiodinium*.

4.10.3 Threats to the Species

Current threats include: thermal stress, acidification, disease, pollution, and exploitation. The harvest of giant clams is for both subsistence purposes (e.g., giant clam adductor, gonad, muscle, and mantle tissues are all used for food products and local consumption), as well as commercial purposes for global international trade (e.g., giant clam shells are used for a number of items, including jewelry, ornaments, soap dishes). The extent of each of these threats is largely unknown. Blidberg et al. (2000) studied the effect of increasing water temperature on *T. gigas, T. derasa,* and *H. hippopus* at a laboratory in the Philippines. *H. hippopus* experienced increased respiration and production of oxygen in elevated temperatures and was therefore more sensitive to higher temperature than the two other species tested. After 24 hours at ambient temperature plus 3°C, however, no bleaching was observed for any of the species. In a lab experiment, short-term temperature increases of 3 °C resulted in *T. squamosa* maintaining a high photosynthetic rate but displaying increased respiratory demands (Elfwing et al. 2001). Watson et al. (2012) showed that a combination of increased ocean CO_2 and temperature are likely to reduce the survival of *T. squamosa*. Specifically, in a lab experiment, *T. squamosa* juvenile survival rates decreased by up to 80 percent with increasing pCO_2 and decreased with increasing seawater temperature for a range of temperatures and pCO_2 combinations that mimic those expected in the next 50 to 100 years. The susceptibility and impacts of disease on *T. squamosa* are not known, but incidences of mortality from rickettsiales-like organisms in cultured clams in the western Pacific, one in the Philippines and one in Kosrae have been documented (Norton et al. 1993).

4.10.4 Conservation of the Species

T. squamosa is listed in CITES Appendix II, is an ESA candidate species and is therefore a consultation species under the UES.

4.11 Humphead wrasse

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

4.11.1 Distribution and Abundance

The humphead wrasse is widely distributed on coral reefs and nearshore habitats throughout much of the tropical Indo-Pacific Ocean. The biogeographic range of the humphead wrasse spans from 30° N to 23° S latitude and includes the Red Sea south to Mozambique in the Indian Ocean, from southern Japan in the northwest Pacific south to New Caledonia in the south Pacific and into the central Pacific Ocean including French Polynesia. The humphead wrasse has been recorded from many islands of Oceania including Kwajalein Atoll, but appears to be absent from the Hawaiian Islands, Johnston Island, Easter Island, Pitcairn, Rapa, and Lord Howe Island with the exception of occasional waifs (Randall et al. 1978).

Although humphead wrasses are widely distributed, natural densities are typically low, even in locations where habitats are presumably intact. Unfished or lightly fished areas have densities ranging from 2–27 individuals per 10,000 square meters of reef. At sites near human population centers or at fished areas, densities are typically lower by tenfold or more and in some locations humphead wrasse are rarely observed (Sadovy et al. 2003). Total abundance throughout its range is difficult to estimate because survey methods may not cover all habitable areas. Existing information suggests that humphead wrasse populations are most abundant and stable in the Indian Ocean.

The humphead wrasse is known to occur in the vicinity of Illeginni Islet. As was found in other studies (Donaldson and Sadovy 2001), the humphead wrasse appears to occur in low densities throughout the Kwajalein Atoll area in NMFS and USFWS biennial surveys. Occurrence records of humphead wrasse suggest a broad, but scattered distribution at USAKA with observations of the species at 26% (32 of 125) of sites at 10 of the 11 surveyed islets since 2010. Adult humphead wrasses have been recorded in seaward reef habitats at Illeginni Islet (shallowest depths approximately 5 m deep (USFWS and NMFS 2012; NMFS and USFWS 2018). Although encountered on numerous occasions at USAKA, direct density measures of humphead wrasse have not been obtained. The adults of this species may range very widely, with typically four or fewer individuals observed within a broad spatial reef area (Dr. R. Schroeder pers, comm.). Two neighboring seaward reef flat sites in 2008 were noted to have adult humphead wrasse present (USFWS 2011); thus, a total of 24 adult individuals might be exposed to potential GBSD impacts in this region. Absent a direct physical or sound related impact, the adults might be expected to show temporary curiosity, altered feeding patterns, and/or displacement.

Shallow inshore branching coral areas with bushy macro-algae, such as those which may exist along the shallow lagoon reef flat at Illeginni Islet, have been noted as potential essential nursery habitat for juvenile humphead wrasse (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 2014a). 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 humphead wrasse, 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 2014b).

Humphead wrasse have been observed to aggregate at discrete seaward edges of deep slope drop-offs to broadcast spawn in the water column; they do not deposit their eggs on the substrate (Colin 2010). This type of behavior is not known at Illeginni Islet, but it may exist; however, similar habitat would occur in nearby waters. The flow dynamics of developing fish eggs and larvae around Illeginni Islet are not understood. Initial flow may be away from the islet, with future return or larval/adult source dynamics from another area. No information exists to support any reasonable estimation of potential ARRW impacts to humphead wrasse eggs and developing larvae (NMFS 2014a).

4.11.2 Life History Characteristics Affecting Vulnerability to Proposed Action

The humphead wrasse is the largest member of the family Labridae. The humphead wrasse is distinguished from other coral reef fishes, including other wrasses, due primarily to its large size along with its fleshy lips in adults (Myers 1999), prominent bulbous hump that appears on the forehead in larger adults of both sexes, and intricate markings around the eyes (Marshall 1964; Bagnis et al. 1972; Sadovy et al. 2003).

Similar to other wrasses, humphead wrasses forage by turning over or crushing rocks and rubble to reach cryptic organisms (Pogonoski et al. 2002; Sadovy et al. 2003 citing P.S. Lobel, pers. comm.). The thick fleshy lips of the species appear to absorb sea urchin spines, and the pharyngeal teeth easily crush heavy-shelled sea snails in the genera *Trochus* spp. and *Turbo* spp. The humphead wrasse is also one of the few predators of toxic animals such as boxfishes (*Ostraciidae*), sea hares (*Aplysiidae*), and crown-of-thorns starfish (*Acanthaster planci*) (Randall 1978; Myers 1989; Thaman 1998; Sadovy et al. 2003).

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

Field reports reveal variable humphead wrasse spawning behavior, depending on location (Sadovy et al. 2003; Colin 2010). Spawning can occur between several and all months of the year, coinciding with certain phases of the tidal cycle (usually after high tide) and possibly lunar cycle (Sadovy et al. 2003; Colin 2010). Spawning can reportedly occur in small (< 10 individuals) or large (≤ 100 individuals) groupings, which can take place daily in a variety of reef types (Sadovy et al. 2003; Sadovy de Mitcheson et al. 2008; Colin 2010). Based on available information, it is suggested that the typical size of female sexual maturation for the humphead wrasse occurs at 40–50 cm TL (Sadovy de Mitcheson et al. 2010). Choat et al. (2006) estimated length at first maturity as 45–50 cm FL for females (6–7 years) and 70 cm FL (9 years) for males.

4.11.3 Threats to the Species

The ERA team identified four major threats to humphead wrasse: 1) habitat destruction, modification, or curtailment; 2) overutilization for commercial, recreational, scientific or educational purposes; 3) disease or predation; 4) the inadequacy of existing regulatory mechanisms; and 5) natural and other man-made factors. Habitat destruction, overfishing, and inadequacy of existing regulatory mechanisms, and some man-made factors such as pollution are threats locally throughout portions of its range. However, the ERA team concluded that four of the five threats evaluated are not significant risks to extinction. Natural and man-made factors, namely climate change, were noted as a small to moderate effect on species risk of extinction.

4.11.4 Conservation of the Species

Humphead wrasse is listed in CITES Appendix II, and has been retained as a consultation species under the UES.

5 ENVIRONMENTAL BASELINE

The UES does not specifically describe the environmental baseline for a Biological Opinion. However, under the ESA, environmental baselines include the past and present impacts of all state, federal or private actions and other human activities in the Action Area, anticipated impacts of all proposed federal projects in the Action Area that have already undergone formal or early section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process (50 CFR 402.02). The Consultation Handbook further clarifies that the environmental baseline is "an analysis of the effects of past and ongoing human and natural factors leading to the current status of the species, its habitat (including designated critical habitat), and ecosystem, within the Action Area" (FWS and NMFS 1998). The purpose of describing the environmental baseline in this manner in a biological opinion is to provide context for effects of the proposed action on listed species. We apply the ESA standards consistent with the intent of the UES agreement in our effects analysis. As described in Sections 2 and 3 above, the action area where the proposed action may adversely affect consultation species consists of the marine waters adjacent to Illeginni Islet at Kwajalein Atoll, RMI and in the KMISS area.

The Marshall Islands consist of 29 atolls and five islands aligned in two roughly parallel northwest-southeast chains: the northeastern Ratak Chain and the southwestern Ralik Chain. The total land area is about 70 square miles (mi^2), and the total lagoon area is about 4,500 (mi^2). Kwajalein Atoll is located near the center of the island group, about eight degrees above the equator, and is one of the largest coral reef atolls in the world. The past and present impacts of human and natural factors leading to the status of UES-protected species within the action area include coastal development, armed conflict, direct take, fishing interactions, vessel strikes and groundings, marine debris, and climate change.

Kwajalein Atoll was the site of heavy fighting during World War II (1940s), when the U.S. took it from the Japanese. Many of the islets have been heavily modified by dredge and fill construction operations by both the Japanese and U.S. forces. More recently, the RMI has provided eleven islets around the rim of Kwajalein Atoll for the use by the U.S. Government as part of the RTS. Hundreds of U.S. personnel live on some of the islets, and Marshallese workers commute daily between the U.S. occupied islets and the ones on which they reside. Vessel traffic occurs regularly between the islets, and to and from the atoll. This includes fishing boats, personnel ferries, military service craft, visiting military ships, and cargo vessels that supply the peoples of Kwajalein Atoll. For more than 18 years, the USAKA has participated in testing hypersonic vehicles from ICBM and other flight tests launched from Vandenberg AFB and other locations. Vehicle impacts from such tests have occurred and continue to occur on and in the vicinity of Illeginni Islet and in adjacent ocean waters. In the Opinion on the Minuteman III operations through the year 2030 it was estimated that 49,645 colonies of the 15 species of UES corals and 117 top shell snails may be killed (NMFS 2015).

On May 16, 2005, we issued a letter of concurrence with the USAF's "not likely to adversely affect" determination for sea turtles and marine mammals under our jurisdiction. It is important to note that sea turtles are under the jurisdiction of the FWS while in terrestrial habitats, whereas they are under our jurisdiction when in marine habitats. Therefore, any impacts on hauled-out or nesting adult turtles, eggs in nests, or hatchlings before they reach the water, were considered in the 2005 FWS Opinion, not in our letter of concurrence.

On March 2, 2017, the U.S. Navy SSP consulted with NMFS on the effects of a near identical action, the FE-1. NMFS concluded in a biological opinion dated May 12, 2017 that the FE-1 would not jeopardize 59 marine ESA/UES consultation species." (PIR-2017-10125; I-PI-17-1504-AG). In that opinion, NMFS estimated that the action would result in up to up to 10,417 colonies of UES consultation corals (as quantified in table 7) could experience complete mortality, up to four top shell snails may be killed by the proposed action, and up to 90 clams, and 108 humphead wrasses could be injured or killed by the proposed action. The target site was the exact same as this proposed action and made an impact on land and not in water. No take was quantified for this action.

On February 12, 2019, USASMDC/ARSTRAT, consulted on the Air-launched Rapid Response Weapon (ARRW) Flight Tests NMFS' Biological Opinion was dated July 30, 2019 (PIRO-2019-00639; I-PI-19-1751-AG). This missile test is expected to impact the same islet targeted in this proposed action. As with the FE-1 and FE-2, impact is expected to occur on land, but could occur in water. In that opinion, NMFS estimated that the action would result in up to 10,417 colonies of UES consultation corals could experience complete mortality, up to four top shell snails may be killed by the proposed action, and up to 90 clams, and 108 humphead wrasses could be injured or killed by the proposed action.

On July 4, 2019, we completed informal consultation on the effects of launching a THAAD missile and subsequent intercept of a medium-range ballistic missile over the Pacific Ocean concluding the operation was not likely to adversely affect 44 species protected under the standards and procedures described in the Environmental Standards and Procedures for U.S. Army Kwajalein Atoll (PIRO-2019-01962; I-PI-19-1769-AG). This test is expected to launch from a neighboring islet within USAKA.

On June 14, 2018, USASMDC/ARSTRAT, on behalf of the U.S. Navy SSP, requested consultation on the effects of launching a single Flight Experiment-2 (FE-2) missile from the PMRF on Hawaii, across the Pacific, and impact at Kwajalein Atoll. NMFS concluded in a Biological Opinion dated September 27, 2019 that the FE-2 would not jeopardize any of the marine ESA/UES consultation species covered under that consultation (PIR-2019-02607; I-PI-19-1782-AG). In that opinion, NMFS estimated that the action would result in up to 10,404 colonies of UES consultation corals (as quantified in Table 10) could experience complete mortality, up to 4 top shell snails, 108 humphead wrasse, and up to 75 clams could be killed by the proposed action. The target site was the exact same as this proposed action and made an impact on land and not in water.

These estimates are likely higher than what the total impacts will be due to the unlikely event of a shoreline impact and the data the estimates were based on. The estimates were based on surveys that have been conducted throughout the area but not in the impact zone. A survey was completed after these estimates were made and some of the corals that were predicted to be in the area were not observed and others were observed at densities lower than what had been estimated (NMFS 2017a). Additional surveys could show that they are indeed in the area but not at higher levels than estimated. Direct take through harvest continues in the RMI for several of the UES consultation species. For example, sea turtles, black lip pearl oysters, and top shell snails (all of which are UES consultation species) are considered a food source or of economic value by many RMI nationals. The harvest of these and other UES-protected marine species is believed to continue on most of the inhabited islands and islets of the RMI, with the possible exception of the USAKA-controlled islets, where access is limited and the UES prohibits those activities. However, the level of exploitation is unknown, and no concerted research or management effort has been made to conserve these species in the RMI. No information is currently available to quantify the level of impact direct take is having on consultation species in the Marshall Islands.

Despite the development, wartime impacts, and human utilization of marine resources mentioned above, the atoll's position at the center of the Pacific Ocean is far from highly industrialized areas, and its human population remains relatively low. Consequently, the water quality level of the lagoon and the surrounding ocean is very high, and the health of the reef communities, along with the overall marine environment of Kwajalein Atoll, borders on pristine.

Climate change may be affecting marine ecosystems at Kwajalein Atoll. Climate refers to average weather conditions within a certain range of variability. The term climate change refers to distinct long-term changes in measures of climate, such as temperature, rainfall, snow, or wind patterns lasting for decades or longer. Climate change may result from: natural factors, such as changes in the Sun's energy or slow changes in the Earth's orbit around the sun; natural processes within the climate system (e.g., changes in ocean circulation); and human activities that change the atmosphere's makeup (e.g., burning fossil fuels) and the land surface (e.g., cutting down forests, planting trees, building developments in cities and suburbs, etc.), also known as anthropogenic climate change (U.S. Environmental Protection Agency). The global mean temperature has risen 0.76°C over the last 150 years, and the linear trend over the last 50 years is nearly twice that for the last 100 years (Solomon et al. 2007). Sea level rose approximately 17 cm during the 20th century (Solomon et al. 2007) and further increases are expected. Climate change is a global phenomenon so resultant impacts have likely been occurring in the action area. However, scientific data describing impacts in the action area are lacking, and no climate change-related impacts on UES-protected species within the action area have been reported to date.

Climate change-induced elevated water temperatures, altered oceanic chemistry, and rising sea level may be contributing to changes to coral reef ecosystems, and is likely beginning to affect corals and mollusks found in the action area. Globally, climate change is adversely affecting many species of corals. Increasing thermal stress due to rising water temperatures has already had significant effects on most coral reefs around the world. It has been linked to widespread and accelerated bleaching and mass mortalities of corals around the world over the past 25 years (Brainard et al. 2011). As the atmospheric concentration of CO_2 has increased, there has been a corresponding reduction in the pH of ocean waters (acidification). As ocean acidity increases, the calcium carbonate saturation state of the water decreases. Increased ocean acidity has the potential to lower the calcium carbonate saturation state enough to slow calcification in most corals and may increase bioerosion of coral reefs. It is thought to adversely affect fertilization, larval settlement, and zooxanthellae acquisition rates for corals, and can induce bleaching more so than thermal stress, and tends to decrease growth and calcification rates (Brainard et al. 2011). By the middle of this century, ocean acidity could lower calcium carbonate saturation to the point where the reefs may begin to dissolve (Brainard et al. 2011).

Attempting to determine whether recent biological trends are causally related to anthropogenic climate change is complicated because non-climatic influences dominate local, short-term biological changes. However, the meta-analyses of 334 species and the global analyses of 1,570 species show highly significant, nonrandom patterns of change in accord with observed climate warming in the twentieth century. In other words, it appears that these trends are being influenced by climate change-related phenomena, rather than being explained by natural variability or other factors (Parmesan and Yohe 2003). However, the implications of these changes are not clear in terms of population level impacts, and data specific to the action area are lacking. Over the long-term, climate change-related impacts could influence the biological trajectories of UES-protected species on a century scale (Parmesan and Yohe 2003). However, due to a lack of scientific data, the specific effects climate change could have on these species in the future are not predictable or quantifiable to any degree that would allow for more detailed analysis in this consultation (Hawkes et al. 2009).

6 EFFECTS OF THE ACTION

In this section of a biological opinion, we assess the probable effects of the proposed action on UES-protected species. In Effects of the Action sections of biological opinions, NMFS presents the results of its assessment of the probable effects of federal actions on threatened and endangered species and designated critical habitat that are the subject of a consultation. According to 50 CFR 402.02, Effects of the Action "are all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action. Furthermore, 50 CFR 402.17 defines reasonably certain to occur as "A conclusion of reasonably certain to occur must be based on clear and substantial information, using the best scientific and commercial data available. Factors to consider when evaluating whether activities caused by the proposed action (but not part of the proposed action) or activities reviewed under cumulative effects are reasonably certain to occur include, but are not limited to: (1) past experiences with activities that have resulted from actions that are similar in scope, nature, and magnitude to the proposed action;(2) existing plans for the activity; and (3) any remaining economic, administrative, and legal requirements necessary for the activity to go forward (50 CFR 402.02). The effects of the action are considered within the context of the Status of the Species, together with the Environmental Baseline and Cumulative Effects sections of this Opinion to determine if the proposed action can be expected to have direct or indirect effects on UES-protected species that appreciably reduce their likelihood of surviving and recovering in the wild by reducing their reproduction, numbers, or distribution (50 CFR 402.02), otherwise known as the jeopardy determination. The actions are not expected to adversely affect any essential features of critical habitat has been designated in the action area.

Approach. We determine the effects of the action using a sequence of steps. The first step identifies potential stressors associated with the proposed action with regard to listed species. We may determine that some potential stressors result in insignificant, discountable, or beneficial effects to listed species, in which case these potential stressors are considered not likely to adversely affect protected species, and subsequently are considered no further in this Opinion. Those stressors that are expected to result in significant negative (i.e., adverse) effects to listed species are analyzed via the second, third, and fourth steps described below.

The second step identifies the magnitude of the stressors (e.g., how many individuals of a particular species would be exposed to the stressors; *exposure analysis*). In this step of our analysis, we try to identify the number, age (or life stage), and gender of the individuals that are likely to be exposed to a proposed action's effects, and the populations or subpopulations those individuals represent.

The third step describes how the exposed individuals are likely to respond to the stressors (*response analysis*). In this step, we determine if the stressors are likely to result in any adverse effects on exposed individuals.

The final step in determining the effects of the action is to establish the risks those responses pose to listed resources (*risk analysis*). The risk analysis is different for listed species and designated critical habitat. However, as mentioned above, the action area includes no designated critical habitat, thus it is not considered in this Opinion. Our jeopardy determinations must be based on an action's effects on the continued existence of UES-protected species within USAKA. Because the continued existence of listed species depends on the fate of the populations that comprise them, the viability (probability of extinction or probability of persistence) of listed species depends on the viability of their populations.

6.1 Stressors

As described above in Section 3, we believe that the proposed action would cause six stressors that may affect the consultation species considered in this consultation: exposure to elevated noise levels; direct contact from payload impact/shockwaves; exposure to hazardous materials; disturbance from human activity and equipment operation; collision with vessels; and long-term additions of man-made objects in the ocean. Of those stressors, direct contact from payload impact/shockwaves, is the only stressor that is likely to adversely affect consultation species. The remaining stressors are expected to have insignificant effects (i.e. effects would not result in take) and/or exposure is discountable (extremely unlikely to occur), and those stressors are discussed no further in this Opinion. Similarly, Section 3 described why all of the species identified in Table 1 are unlikely to be adversely affected, and therefore considered no further in this Opinion. In summary, the seven coral species, top shell snail, and two giant clams, and the humphead wrasse identified in Table 2 may be hit by the falling payload or by ejecta, or be significantly affected by concussive forces during the planned payload impacts (up to three) on Illeginni Islet.

Note: Within the seven coral species that may be adversely affected by the proposed action, the effects are expected to be practically identical. Addressing the species individually would significantly increase the length of this Opinion with no discernible improvement in the evaluation. Therefore, all seven coral species are referred to together as "corals", unless an individual species needs to be identified due to some unique sensitivity or response. The same is true for the two clam species.

6.2 Exposure to Impact by GBSD Reentry Vehicles

This section analyzes the proposed action's potential for exposing UES-consultation corals, giant clams, and top shell snails to being hit by up to three GBSD payload or ejecta thereof planned to strike on Illeginni Islet. This analysis is based on the distribution and density report completed for the MM III proposed action, the follow-up survey post action, and on personal communication with the survey team (NMFS 2014b, NMFS 2017a, Kolinski pers. comm. 2015), and the FE-2 flight test (SSP 2019). We believe that the distribution and density report likely over-estimates the number of coral and mollusk species that may be within the action area at Illeginni, but that it represents the best available information to make those estimates.

The quantitative estimates of species distribution and abundance within the potentially affected areas at Illeginni are based on surveys of 136 sites around the 11 USAKA islets, including four sites around Illeginni (NMFS 2014b). Species observed to occur on reef flat, crest, and gently sloping substrates around USAKA islets at depths less than or equal to 35 feet water depth were considered as potentially being present within the MMIII, FE-1, THAAD, and FE-2 impact area and hence the GBSD payload impact area. Because the available survey information also includes the observed distribution and abundance of the affected consultation species in numerous habitat types around the 11 USAKA islets and at 35 survey sites throughout the mid-atoll corridor (MAC), we believe that the existing information also serves as a reasonable foundation to estimate the distribution and abundance of these organisms throughout USAKA. Analyses of effect of MMIII reentry vehicle (USAFGSC and USASMDC/ARSTRAT 2015), FE-1 (U.S. Navy 2017), and FE-2 (U.S. Navy 2019) payload impacts at Illeginni Islet were conducted based on coral, mollusk, and fish densities extrapolated from coral presence and abundance from similar reef habitats throughout USAKA. In 2017, NMFS completed a report with revised density estimates for many consultation species based on 2014 assessments of the reefs adjacent to the impact area at Illeginni Islet (NMFS-PIRO 2017a and 2017b). The areas surveyed for this assessment encompassed all of the Affect Area reef habitat on the lagoon side and 99% of the reef area on the ocean side (NMFS 2017a and 2017b). Additionally, NMFS conducted a survey within USAKA at two launch sites in 2018 to provide data for the THAAD operation (NMFS 2018). Based on coverage area of this assessment, these data are considered the best available information for coral and mollusk species presence and density in the affect area.

The humphead wrasse (*Cheilinus undulatus*) was not observed during the 2014 surveys for the most recent assessment of consultation organisms at Illeginni Islet (NMFS 2017a); however, this species has been recorded in both ocean-side and lagoon-side habitats adjacent to the impact area in other surveys. Since the humphead wrasse is a highly mobile species, the extrapolation methods for estimating density which were previously used for impact analysis are still considered the best available data for a conservative approach. Therefore, humphead wrasse densities were estimated by NMFS PIRO based on quantitative data collected during the 2008 species inventory, recent impact assessments on natural substrates at USAKA and, for egg and fish recruit derivations, from the literature (NMFS 2014b). *Cheilinus undulatus* typically occurs in broadly distributed low numbers and has been seen near Illeginni islet. It was estimated for the similar FE-2 single payload impact that eight adults may occur within the entire potential ocean-side affected area, and 0-100 juveniles could occur within the entire potential lagoon-side affected area. The same assumptions would be made for this consultation for each possible test, where it was discussed in Section 2 that up to three payload impacts could occur at Illeginni Islet. Therefore, we would estimate that up to 24 adults and 300 juveniles could be adversely affected (for up to the three anticipated payload impacts at Illeginni, with the assumption that each test could impact a different area each time).

There is a chance that the GBSD payloads could strike the water's edge along the lagoon or ocean shore at Illeginni. Empirical observations of historical reentry vehicle impacts from MMIII tests in very shallow waters found that most debris was contained within the crater and ejecta were concentrated within 1.5 to 3 m of the crater rim (USAFGSC and USASMDC/ARSTRAT 2015). As with MMIII reentry vehicles, FE-1, FE-2, or THAAD tests, we estimate that the payload land impacts may produce ejecta and debris concentrated near the impact site and extending outward to 91 m. Empirical evidence from MMIII tests corroborates predictions of the propagation of shock waves associated with impact were approximately 37.5 m through the adjacent reef from the point of impact on the shoreline (USAFGSC and USASMDC/ARSTRAT 2015). Coral, and mollusk mortality or injury could occur from impacts by shock/vibration. These reef impacts were based on observations of damaged corals, which can be affected by ground borne vibration.

Habitat suitability for consultation species is lowest along the water's edge and with the exception of sandy patches, typically increases with distance from shore. Only a portion of the area of potential direct contact effect offshore of the Illeginni Islet impact area is suitable habitat for consultation species. Based on the 2014 NMFS surveys of the area offshore of the RV land impact zone and the best professional judgment of NMFS survey divers, approximately 80 percent of the lagoon-side survey area and 75 percent of the ocean-side survey area are considered potentially viable habitat for consultation coral, mollusk, and reef-associated fish species (Figure 8) (NMFS 2019). Using these estimates of suitable habitat and assuming the ejecta would be on only one side of the islet for a given test (i.e., either on the lagoon or ocean sides of the islet); the area of lagoon- side and ocean-side suitable habitat which may be impacted by debris was calculated. Using these percentages of suitable habitat likely results in an overestimate of the area of potential effect because habitat suitability for consultation species is lowest along the water's edge (where debris is more likely to occur) and with the exception of sandy patches, typically increases with distance from shore (NMFS 2019).

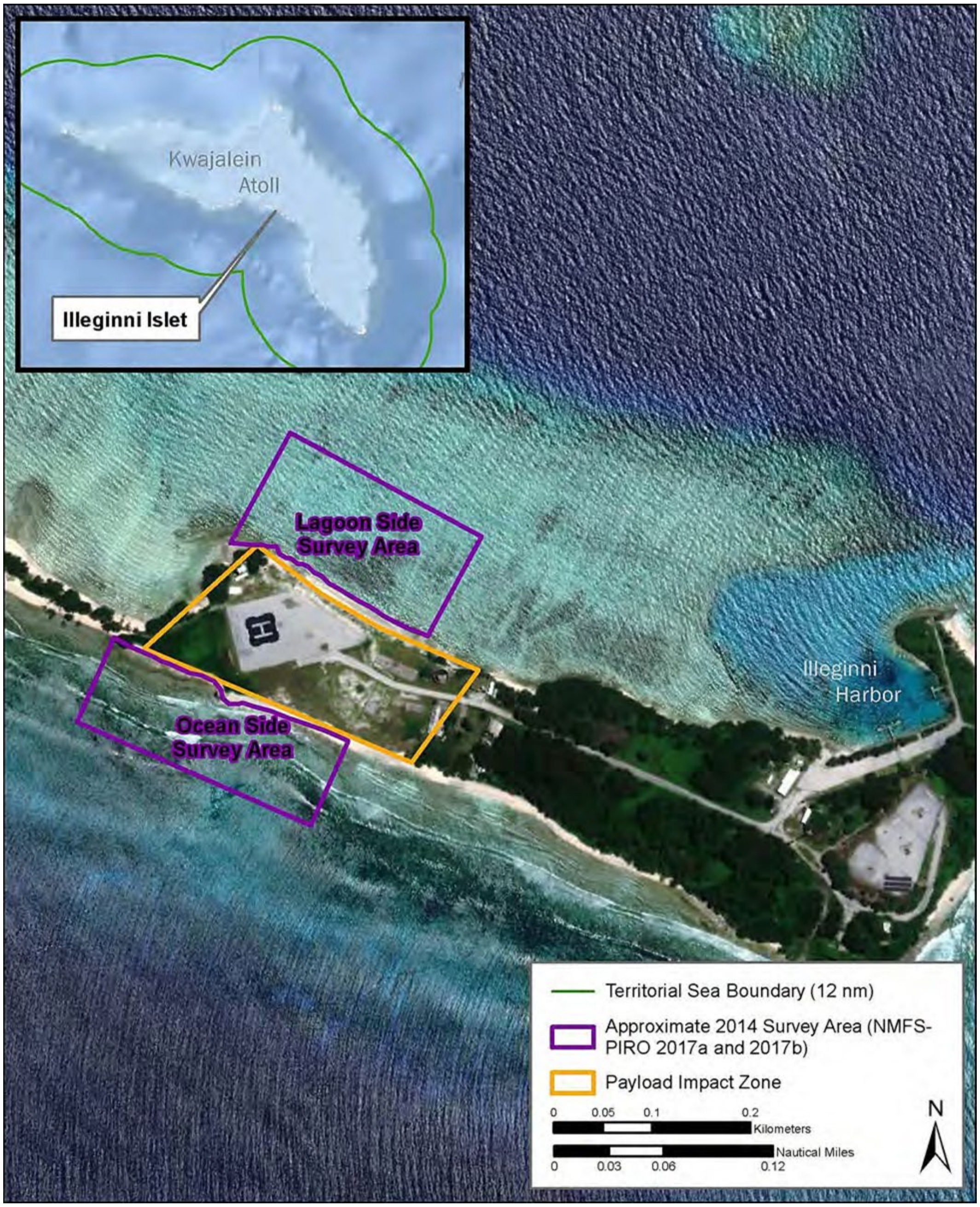

Figure 8. NMFS 2014 Marine Resource Survey Areas at Illeginni Islet, Kwajalein Atoll (provided by U.S. Army).

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

Also, the area within the shockwave range of effect would be completely contained within the area at risk for ejecta impacts. The anticipated worst-case scenario of a payload land impact at Illeginni islet is a shoreline strike, which would result effects that would extend outward from the point of strike. On both sides of Illeginni Islet, the area may potentially be affected debris fall. 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 was selected as the worst-case scenario. Although the exact shape of the affect area is impossible to estimate, the seaward portion of such an area is conceptually illustrated as a rough semi-circle on the lagoon and ocean sides of Illeginni Islet with a radius of 91 m (Figure 9).

Figure 9. Representative Maximum Direct Contact Affect Areas for a Shoreline Payload Impact at Illeginni Islet, Kwajalein Atoll.

If the worst- case scenario of a shoreline RV impact is considered, coral colonies might be exposed to shock waves. As discussed above, habitat suitability for consultation species is lowest along the water's edge (where shock waves would be most intense) and typically increases with distance from shore (NMFS 2019). If shock waves strong enough to damage corals might extend out 37.5 m from impact, shock waves might occur in approximately 2,209 m^2 (2,642 yd^2) of nearshore marine areas. In the event of a shoreline RV impact, it is likely that some coral colonies would be affected, but the most likely realized effects would be cracks in the colony or broken branches or plates. As discussed for direct contact above, fracturing or broken branches would injure the soft tissue near the break but affecting some polyps of a colony does not necessarily constitute harm to the individual as the colony can continue to exist even if the colony is damaged.

Since the maximum debris exposure and potential shock wave exposure areas overlap and since harmed individuals should be counted only once in determining the effects of the Proposed Action, the effects on nearshore coral species were calculated based on the potential debris exposure area.

The estimated total number of colonies or individuals exposed for all three tests with land RV impact was calculated based on the 99% upper confidence level of the bootstrap mean densities for the potentially affected colonies or individuals exposed during a single test multiplied by three (Table 7). The number of colonies or individuals were based on a 2014 assessment of the reef areas offshore of the Illeginni Islet Impact Zone (NMFS-PIRO 2017a and 2017b). Coral colony, individual mollusk mean densities and 99% upper confidence level (UCL) were provided by NMFS-PIRO (2017a and 2017b). If it is assumed that each potential test involving land impacts would have a shoreline impact (a worst-case scenario) and assuming each test would expose different marine areas to debris, an estimated 31,224 UES-consultation coral colonies and 228 individual mollusks might be exposed to direct contact from debris from a total of three anticipated payload impacts based on mean densities in the area.

Table 7. Estimated numbers of consultation coral colonies, and individual mollusks and fish in affected habitat from three anticipated payload impacts.

Scientific Name	Species	Colonies or Individuals Affected
Corals		
Acropora microclados	No Common Name	51
A. polystoma	No Common Name	51
Cyphastrea agassizi	No Common Name	42
Heliopora coerulea	No Common Name	14,049
Pavona venosa	No Common Name	42
Turbinaria reniformis	No Common Name	42
Pocillipora meandrina	Cauliflower coral	16,947
Mollusks		
Tectus niloticus	Top Shell Snail	9
Hippopus hippopus	Giant clam	186
Tridacna squamosa	Giant clam	33
Fish		
Cheilinus undulates	Humphead wrasse	324 (24 adults/300 juveniles)

6.3 Response to Falling Missile Components

This section analyzes the responses of UES-consultation corals, top shell snails, giant clams, and humphead wrasse that may be exposed to being hit by the GBSD payloads and/or ejecta.

The GBSD payloads would be traveling at hypersonic velocity when it impacts the islet. The kinetic energy released into the substrate would be similar to the detonation of high explosives. The payload will effectively "explode", with some of its mass reduced to very fine particles ("aerosolized") and the remainder reduced to an undescribed range of fragment sizes. The substrate at the impact site would be blasted into a range of fragment sizes ranging from powder to larger rocks toward the outer edges of the crater. Some debris and substrate rubble would remain in the crater. The remainder would be thrown from the crater (ejecta). Initially, some of the ejecta would be moving at high velocity (bullet speeds). Some ejecta would move laterally, some would travel upward then fall back down up to 91 m from the impact site. The substrate immediately around the crater would be covered by larger chunks of ejecta from the outer edges of the crater as well as finer material that was thrown more vertically before falling back down. The movement of ejecta away from the crater would act to spread it out (scatter) over an increasing area, with decreasing available material being scattered over an increasing area. The velocity of the ejecta would also diminish with distance.

The intensity of the payload impact, and the uniformity of exposure to ejecta and the shockwave would decrease with distance from the point of impact. Any corals and top shell snails directly beneath the payload, or within the crater radius are expected to be instantly killed, with very little left of the organisms that would be recognizable. Beyond the crater, corals and top shell snails would be exposed to ejecta and the ground borne shockwave. Corals and top shell snails immediately beyond the crater would likely experience mortality from impact by high-velocity ejecta, from burial under mobilized crater material, or from exposure to the ground borne shockwave.

The response of corals to ejecta and the ground borne shockwave would depend largely on the scale and intensity of the exposure as well as the morphology of the coral. Impact by high-velocity dense ejecta (rock or metal), could fracture the hard structure of corals and would likely injure or destroy soft tissues. Fracturing would depend largely on the size and intensity of the impact and on morphology of the impacted coral. Plate-forming and branching corals are more easily broken than large massive or encrusting forms. Fractures due to payload impact are expected to range from pulverization of colonies in and close to the crater, to cracks and/or loss of branches in colonies toward the outer edge of effect. Additionally, exposure to the ground based shockwave could also fracture or dislodge coral colonies out to about 37.5 m from the payload impact. Because the coral skeletons are hard rock-like structures that are rigidly fixed to the hard substrate through which the shock wave would travel, much of the available energy in the substrate can be transferred directly into the coral's skeletal structure. If the shockwave is intense enough, the coral's structure may crack or fracture and/or it may become unattached from the substrate. At close ranges, impact by lower velocity and/or lower density ejecta could affect the soft tissues of corals, ranging from burial to scouring away all or most of the living polyps and interconnecting soft tissues from a colony. At greater ranges, localized damage of a small part of a colony is possible.

Pulverization of a colony's structure, deep burial, or loss of a large proportion of a colony's soft tissue would likely result in the mortality of the colony. Partial fracturing of a coral skeleton and/or dislodgement of a coral from the substrate due to ejecta impact or from exposure to the ground based shock wave would injure the soft tissues at and around the break. Re-growth of soft tissues has energetic costs that could slow other growth and reproduction. Exposed areas of coral skeleton are prone to bioerosion and overgrowth by algae and certain sponges. Large areas of damaged or dead tissue could result in the introduction of algae that may prevent the regeneration of healthy coral tissue, or that may overcome the whole colony. Damaged and stressed tissues may also be more susceptible to infection by coral diseases that may hinder or prevent healing to the point that the colony dies.

Fragmentation is a form of asexual reproduction in some branching corals, resulting in the development of new, but genetically identical colonies. Bothwell (1981) reports that several *Acropora* species successfully colonize through fragmentation and translocation of fragments by storm-driven waves. However, not all coral fragments, or dislodged colonies would be expected to survive. Survival would depend largely on where a fragment falls and how it is oriented after it settles to substrate. A fragment or colony is likely to die if the living tissue is on the underside of the fragment or if the fragment settles into fine sediments. Additionally, in areas that experience regular high surf, such as the ocean side reef at Illeginni, loose coral fragments and colonies could repeatedly become mobilized by the waves. This reduces the likelihood of their survival, and potentially injures additional coral colonies should the fragments be cast against them.

Based on the available information, we believe that the numbers of coral colonies, identified above in Table 7, represent a conservative yet reasonable estimate of the corals that may be adversely affected by the proposed action. Further, this Opinion conservatively assumes that mortality would result for all exposed coral colonies. This approach is being taken to ensure a precautionary assessment is made of the jeopardy risk for the affected species.

In the case of the top shell snail, the effects of exposure to ejecta and shockwave is expected to quickly diminish to insignificance with distance from the payload impact site. Impact by high-velocity dense ejecta (rock or metal) immediately around the crater could penetrate or fracture an exposed snail's shell, either killing the animal directly, or leaving it vulnerable to predation. Conversely, with movement away from the payload impact site, ejecta would become slower, and the ejecta would have to penetrate increasing water depth to impact the snails. Considering the conical shape and thickness of a top shell snail's shell, most ejecta that may strike one that is under water and at any distance from the payload impact site is likely to be deflected without imparting a significant proportion of its kinetic energy to the shell or the animal within.

Top shell snails immediately around the payload crater may also be buried by ejecta. The potential for burial, and the depth of the material under which a snail may be buried would likely decrease quickly with distance from the payload impact site. Mortality could result if the snail is crushed, smothered, or permanently pinned beneath rubble. Non-lethal effects could include energetic costs and/or foraging impacts.

Exposure to intense ground borne shockwaves could injure the soft tissues of top shell snails. Mortality of the snail is possible if the injury is significant enough. The range to the onset of significant injuries for top shell snails exposed to a ground based payload impact shockwave is unknown, but it is likely much less than that estimated for corals (37.5 m). Top shell snails are not rigidly attached to the substrate as are corals. Instead, they adhere to the reef using a muscular foot. Whereas rigidly attached corals would be directly linked to the substrate such that the energy could readily travel into and along its skeletal structure, the muscular foot of the snail would act to isolate the snail's shell from the vibration, and to reduce the transfer of the energy to other soft tissues and organs. Non-lethal effects could include bruising of the foot and other tissues, which may have energetic costs and/or may have reproductive impacts.

As stated above, habitat suitability for the consultation species is lowest along the water's edge and typically increases with distance from shore. Therefore, top shell snail density would be lowest in the area immediately adjacent to the payload impact site, where ejecta effects and shockwave would be greatest. Conversely, in the areas where top shell snail density would be highest, ejecta would be slower, and it would have to penetrate several feet of water to impact the snails. Based on this, on the robust nature of snails (see Section 4), and the characteristics of its shell, most ejecta that may strike top shell snails is likely to be deflected without imparting any significant proportion of its kinetic energy to the shell or the animal within. In this situation, ejecta impact would result in little more than inducing the affected snail to briefly adhere more tightly to the substrate before resuming normal behaviors. The range to adverse effects from burial and shockwaves would likely be similarly restricted to the area along the water's edge. Therefore, we expect that the nine top shell snails that may be exposed to the combined effects of three payload land strikes (Table 7, above), would be adversely affected by the exposure. Further, this Opinion conservatively assumes that mortality would result for all exposed top shell snails. This approach is being taken to ensure a precautionary assessment is made of the jeopardy risk for the affected species.

In the case of the clams, the effects of exposure to ejecta and shockwave is expected to quickly diminish to insignificance with distance from the payload impact site. Impact by high-velocity dense ejecta (rock or metal) immediately around the crater could penetrate or fracture an exposed clam shell, or damage soft tissue that is exposed possibly killing the animal. Conversely, with movement away from the payload impact site, ejecta would become slower, and the ejecta would have to penetrate increasing water depth to impact the clams. Considering the thickness of a clam shell, most ejecta that may strike one that is under water and at any distance from the payload impact site is likely to be deflected without imparting a significant proportion of its kinetic energy to the shell or the animal within unless it is able to lodge itself in the shell opening.

Clams immediately around the payload crater may also be buried by ejecta. The potential for burial, and the depth of the material under which a clam may be buried would likely decrease quickly with distance from the payload impact site. Mortality could result if the clam is crushed, smothered, or permanently pinned beneath rubble. Non-lethal effects could include feeding impacts if the clam is unable to filter feed due to debris.

Exposure to intense ground borne shockwaves could injure the soft tissues of clams. Mortality is possible if the injury is significant enough. The range to the onset of significant injuries for clams exposed to a ground based payload impact shockwave is unknown. Clams can be buried in substrate or attached to corals which means they would be directly linked to the substrate such that the energy could readily travel into the shell and affect the soft tissue and organs. Non-lethal effects could include bruising of the tissues, which may have energetic costs and/or may have reproductive impacts.

As stated above, habitat suitability for the consultation species is lowest along the water's edge and typically increases with distance from shore. Therefore, clam density would be lowest in the area immediately adjacent to the payload impact site, where ejecta effects and shockwave would be greatest. Conversely, in the areas where clam density would be highest, ejecta would be slower, and it would have to penetrate several feet of water to impact the clams. Based on this, on the robust nature of clams, and the characteristics of its shell, most ejecta that may strike clams is likely to be deflected without imparting any significant proportion of its kinetic energy to the shell or the animal within. In this situation, ejecta impact would result in little more than inducing the affected clam to close before resuming normal behaviors. The range to adverse effects from burial and shockwaves would likely be similarly restricted to the area along the water's edge. Therefore, we expect that 219 clams that may be exposed to the combined effects of a payload land strike (Table 7, above), would be adversely affected by the exposure. As described above, this number is based on the worst-case scenario and under the assumption that the three tests could impact a different area every time and result in mortality. This approach is being taken to ensure a precautionary assessment is made of the jeopardy risk for the affected species.

In the case of the humphead wrasse, it is estimated that there will be up to 300 juvenile, and 24 adult humphead wrasses in the area of impact (worst case scenario expecting mortality from each test). An individual animal could be exposed to ejecta hitting and traveling through the water and from the shock wave produced from the main projectile's impact. An animal subjected to a direct impact, concussive shock waves from the impact, ejecta, or a near miss of ejecta would result in wounding or death. Potential injuries may include cuts, gashes, bruises, broken bones, rupture or hemorrhage of internal organs, amputation, or other broken body parts; any of which could result in an animal's death. Since the arcs (the affected area on the lagoon and the affected area on the ocean) were drawn and estimated based on shoreline strikes on each side, the model assumes mishits on every test, which is highly unlikely to occur. Furthermore, it assumes that ejecta will uniformly spread, especially to the outer extents of those circles (~100 m away). Humphead wrasses were observed beyond the reef crest near the edges of those arcs. As mentioned in previous sections, the USASMDC/ARSTRAT observed the majority of ejecta stayed within a few meters of the impact area. The density of ejecta is expected to decrease with distance from the point of impact (USAFGSC and USASMDC/ARSTRAT 2015). Ejecta is also likely to lose velocity the further it travels from the source. The depth of the water in the 91 m radius is expected to be less than 3 m. Humphead wrasses are generally not surface-dwelling fish where they would be the most vulnerable to strikes. Graham et al. (2015) reports that humphead wrasse are most often encountered on outer reef slopes and reef passes/channels at depths of only a few meters to at least 60 m (Randall 1978); other reports document humphead wrasses to depths of up to 100 m (Russell 2004; Zgliczynski et al. 2013). Graham et al. (2015) further notes at that personal observations from NMFS biologists familiar with the species, documented observations on deep dives and that the species was caught at depths greater than 100 m and up to approximately 180 m by deep gillnet (G. Davis pers. comm. as cited in Graham et al. 2015). On impact, the parts of the payload and substrate will explode into numerous pieces from "aerosolized" bits to mid-sized rocks. The largest sized ejecta is likely to travel through the air slower than smaller and lighter pieces, and fall closer to the source. When ejecta hits the water, it slows down quickly before falling to the reef or substrate. Furthermore, ocean conditions are dynamic in the nearshore (i.e. waves, currents, etc.) and projectiles would lose the majority of their energy within a few inches of the surface. Humphead wrasse, even juveniles, are large and mobile and will likely flee from falling debris as it hits the water.

6.4 Risk

This section analyzes the risk posed by the proposed action for populations of UES-protected marine species at USAKA due to exposure to direct impact and removal from the water as described above. Because this Opinion assumes mortality for all exposed individuals, regardless of the stressor, the risk assessment below focuses on the species impacts from the direct impact.

6.4.1 Risk for coral populations due to expected levels of action-related mortality

As described in the exposure analyses above, up to 31,224 colonies of seven UES-consultation coral species (Table 7) could experience mortality from the payload strikes on Illeginni Islet. This would be due to the combined exposure to direct payload impact, ejecta, and ground based shockwaves. This represents the maximum possible impact associated with this action.

Based on the best information available, we believe that these corals are all widely distributed around the atoll, and that the potentially impacted area represents a very small fraction (not currently quantifiable) of coral-occupied habitat at Illeginni, and likely below 1% of coral-occupied habitat at USAKA. As described above, we further believe that the distribution and abundance of these coral species in similar habitat areas outside of the potentially impacted zones would be similar to their estimated distribution and abundance within the impacted zones, and as such, these 31,224 colonies likely represent a tiny fraction of their species found at Illeginni and across USAKA. Therefore, based on the best available information, we consider the risk negligible that project-related effects from direct payload impact, ejecta, and ground based shockwave would eliminate any of these species at USAKA, or appreciably reduce the likelihood of their survival and recovery at USAKA and across their global range.

6.4.2 Risk for top shell snails due to expected levels of action-related mortality

As described in the exposure and response analyses above, we expect up to nine top shell snails could experience mortality as the result of the planned direct payload impacts, ejecta, and ground based shockwaves. We believe that top shell snails are widely distributed at all of the USAKA islets around the atoll, and that the potentially impacted area represents a very small fraction (not currently quantifiable) of top shell snail-occupied habitat at Illeginni, and likely below 1% of top shell snail-occupied habitat at USAKA. As described above, we further believe that the distribution and abundance of these mollusks in similar habitat areas outside of the potentially impacted zones would be similar to their estimated distribution and abundance within the impacted zones, and as such, these nine top shell snails likely represent a tiny fraction of their species found at Illeginni and across USAKA, and their loss would be virtually indistinguishable from natural mortality levels in the region. Therefore, based on the best available information, we consider the risk negligible that the effects of direct payload impacts, ejecta, and ground based shockwaves would eliminate this species at USAKA, or appreciably reduce the likelihood of its survival and recovery at USAKA and across their global range.

6.4.3 Risk for clams due to expected levels of action-related mortality

As described in the exposure and response analyses above, we expect up to 186 *H. hippopus* and 33 *T. squamosa* clams could experience mortality as the result of the planned direct payload impacts, ejecta, and ground based shockwaves. We believe that both species of clams are widely distributed at all of the USAKA islets around the atoll, and that the potentially impacted area represents a very small fraction (not currently quantifiable) of clam-occupied habitat at Illeginni, and likely below 1% of clam-occupied habitat at USAKA. As described above, we further believe that the distribution and abundance of these mollusks in similar habitat areas outside of the potentially impacted zones would be similar to their estimated distribution and abundance within the impacted zones, and as such, these 219 clams likely represent a tiny fraction of their species found at Illeginni and across USAKA, and their loss would be virtually indistinguishable from natural mortality levels in the region. Therefore, based on the best available information, we consider the risk negligible that the effects of direct payload impacts, ejecta, and ground based shockwaves would eliminate this species at USAKA, or appreciably reduce the likelihood of its survival and recovery at USAKA and across their global range.

6.4.4 Risk for humphead wrasses due to expected levels of action-related mortality

As described in the exposure and response analyses above, we expect up to 324 humphead wrasses could experience mortality as the result of direct payload impacts from all four payload strikes, ejecta, and ground-based shockwave, but more likely minor injury if any, will occur. We believe that humphead wrasse are widely distributed at all of the USAKA islets around the atoll, and that the potentially impacted area represents a very small fraction (not currently quantifiable) of habitat at Illeginni, and likely below 1% of humphead wrasse-occupied habitat at USAKA. As described above, we further believe that the distribution and abundance of these fish in similar habitat areas outside of the potentially impacted zones would be similar to their estimated distribution and abundance within the impacted zones, and as such, these 324 humphead wrasse likely represent a tiny fraction of their species found at Illeginni and across USAKA, and their loss would be virtually indistinguishable from natural mortality levels in the region. Therefore, based on the best available information, we consider the risk negligible that the effects of direct payload impact, ejecta, and ground-based shockwave would eliminate this species at USAKA, or appreciably reduce the likelihood of its survival and recovery at USAKA and across their global range.

7 CUMULATIVE EFFECTS

The UES does not specifically describe "cumulative effects" for a biological opinion. However, Section 161 of the Compact provides that for U.S. Government activities requiring the preparation of an environmental impact statement (EIS) under NEPA, the U.S. Government shall comply with environmental standards that protect public health and safety and the environment that are comparable to the U.S. environmental statutes, including the Endangered Species Act. Although not all USAKA actions that require formal consultation also require the preparation of an EIS, such as this action, we analyze cumulative effects in all USAKA consultations as that term is defined in the ESA implementing regulations. Cumulative effects, as defined in the ESA, are limited to the effects of future State, tribal, local, or private actions that are reasonably certain to occur in the action area considered in this Opinion (50 CFR 402.02). These effects do not include the continuation of actions described under the Environmental Baseline, and future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to Section 7 of the ESA.

The impacts of RMI coastal development, fisheries interactions, vessel groundings, direct take, marine debris, and global climate change are not only expected to continue, they are likely to intensify over time. The intensification of those impacts is expected to cause cumulative effects on UES-protected marine species at USAKA. Continued growth of the human population at Kwajalein Atoll would likely result in increased coastal development, fishing pressure, vessel traffic, and pollution of the marine environment.

Anthropogenic release of CO_2 and other greenhouse gases is considered the largest contributor to global climate change, and it is expected that the release of those gases is not only likely to continue, but the rate of their release is expected to increase during the next century (Brainard et al. 2011). Therefore, global climate change is expected to continue to impact UES-protected marine species and their habitats, especially on those species that are dependent on shallow coastal reefs and shorelines, such corals and marine mollusks.

There is uncertainty associated with the analysis of potential impacts of climate change on species and ecosystems (Barnett 2001). Effects of climate change will not be globally uniform (Walther et al. 2002) and information regarding the magnitude of future climate change is speculative and fraught with uncertainties (Nicholls and Mimura 1998). In particular, there is no comprehensive assessment of the potential impacts of climate change within the action area or specific to UES-protected marine species. In addition to the uncertainty of the rate, magnitude, and distribution of future climate change and its associated impacts on temporal and spatial scales, the adaptability of species and ecosystems are also unknown. Impact assessment models that include adaptation often base assumptions (about when, how, and to what conditions adaptations might occur) on theoretical principles, inference from observed observations, and arbitrary selection, speculation, or hypothesis (see review in Smit et al. 2000). Impacts of climate change and hence its 'seriousness' can be modified by adaptations of various kinds (Tol et al. 1998). Ecological systems evolve in an ongoing fashion in response to stimuli of all kinds, including climatic stimuli (Smit et al. 2000).

The effects of global climate change, the most significant of which for corals are the combined direct and indirect effects of rising sea surface temperatures and ocean acidification, are currently affecting corals on a global scale, particularly in parts of the Caribbean. The return frequency of thermal stress-induced bleaching events has exceeded the ability of many reefs and coral species to recover there. Brainard et al. (2011) report that those effects likely represent the greatest risk of extinction to ESA-candidate corals over the next century. Field observation and models both predict increasing frequency and severity of bleaching events, causing greater coral mortality and allowing less time to recover between events. However, predicting how global climate change may impact particular species remains poorly understood, especially in understudied areas such as USAKA.

The effects of global climate change could act synergistically on corals affected by the proposed action. The ability of impacted corals to respond to the effects of the proposed action could be reduced due to the effects of elevated temperatures and increased ocean acidity, and the longer it takes for impacted corals to recover from the effects of the proposed action, the more likely it becomes that the effects of climate change would synergistically impact those corals. However, the degree to which those synergistic impacts may affect corals over the time required for them to recover from project impacts is unknown.

The effects of global climate change could also act synergistically on mollusks affected by the proposed action. However, no specific information is currently available to assess the impacts. Changes in ocean temperature and chemistry, and rising sea level may be affecting these species because they depend on an exoskeleton that is comprised primarily of calcium carbonate. We expect that minimally, increased acidity could have effects that parallel those described for corals above.

Given the small area and low numbers of individuals expected to be adversely affected by the proposed action, the possible synergistic impacts of climate change combined with the effects of the proposed action are not expected to be significant for the corals, mollusks, and fish considered in this Opinion.

8 INTEGRATION AND SYNTHESIS OF EFFECTS

The purpose of this Opinion is to determine if the proposed action is likely to jeopardize the continued existence of UES-protected marine species at USAKA. "Jeopardize the continued existence of" means to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a UES-protected marine species at USAKA by reducing the reproduction, numbers, or distribution of that species. This Opinion considers the Effects of the Action within the context of the Status of the Species, the Environmental Baseline, and Cumulative Effects as described in Section 7 under "Approach".

We determine if reduction in fitness to individuals of marine consultation species that may result from the proposed action are sufficient to reduce the viability of the populations those individuals represent (measured using changes in the populations' abundance, reproduction, spatial structure and connectivity, growth rates, or variance in these measures to make inferences about the risk of reducing the likelihood of survival and recovery of UES-protected species). In order to make that determination, we use the population's base condition (established in the Status of Listed Species and Environmental Baseline sections of this Opinion), considered together with Cumulative Effects, as the context for the overall effects of the action on the affected populations at USAKA. The following discussion summarizes the probable risks the proposed action poses to corals, top shell snails, giant clams, and the humphead wrasse identified in Section 6.

8.1 Corals

As described in the Effects of the Action section, a total of up to 31,224 colonies of UES-consultation corals (seven species) could be killed through some combination of exposure to direct payload impact, ejecta, and ground based shock wave. Over 99% of the colonies are from two highly abundant and widely distributed species within USAKA; *P. meandrina* and *H. coerulea*.

As discussed in the Status of Listed Species, abundance and trend data are lacking for these corals at USAKA. However, they are all widely distributed around the atoll, with four of the seven corals being known to occur at all USAKA islets. Others are known to occur on at least half of the USAKA islets. All seven species have also been observed at survey sites in the MAC, with three found at over 30 of the 35 sites. It is important to recognize that survey data for USAKA is far from complete. Only a small portion of the total reef area around the USAKA islets and MAC has been surveyed, and surveys to specifically identify and quantify these species are yet to be done. A recent survey was completed at Illeginni Islet in the MM III reef impact area, which is also the area that has been analyzed for impacts from the ARRW payload and the results suggest that the estimate for corals in the area may be lower than what has been estimated (NMFS 2017a). Additionally, NMFS conducted a survey in 2018 at two launch sites in preparation of the THAAD test (NMFS 2018).

As discussed more fully in the Environmental Baseline and Cumulative Effects sections, the effects of continued flight testing, fisheries interactions, direct take, and climate change are expected to continue and likely worsen in the future for these corals. Although many actions at USAKA beyond what are described in the Environmental Baseline and Cumulative Effects sections are uncertain, we do have expected estimates (worst-case scenarios) for the actions described above in those sections, and we acknowledge that there are other federal actions occurring in the Atoll (previous, ongoing and known future actions) impacting these species. For example, the FE-1 testing will remove up to 10,417 coral colonies, the ARRW testing will remove up to 10,417 colonies, and the FE-2 testing will remove up to 10,404 colonies (for a total of up to 31,238 colonies cumulatively). PRD has considered the action's impacts with the other threats incurring on the species, and even with the worst-case scenario (loss of individuals due to this action) added to other losses discussed in the Environmental Baseline and Cumulative Effects sections, we do not expect these actions to result in appreciable reduction of the species.

The proposed action is anticipated to result in the mortality of up to 31,224 coral colonies at Illeginni Islet. These coral colonies represent an extremely small fraction of the total number of colonies found at Illeginni, and even less around USAKA. In the context of this action, the potential loss of these coral colonies is not expected to significantly impact reproduction or to impede the recovery of their species across USAKA and the MAC. Therefore, when taken in context with the status of these species, the environmental baseline, cumulative impacts and effects, the proposed action is not likely to eliminate any of the seven UES consultation corals considered in this Opinion from Illeginni, or appreciably reduce the likelihood of their survival and recovery across USAKA including the MAC.

8.2 Top Shell Snail

As described in the Effects of the Action section, a total of up to nine top shell snails could be killed through some combination of exposure to direct payload impact, ejecta, and ground based shock wave.

As discussed in the Status of Listed Species, top shell snails have been reported at all of the 11 USAKA islets as well as at 59 of 103 survey sites throughout Kwajalein Atoll including all four survey sites on Illeginni. It is important to recognize that survey data for USAKA is far from complete. Only a small portion of the total reef area around the USAKA islets has been surveyed, and surveys to specifically identify and quantify this species are yet to be done. As such, it is possible that the distribution and abundance of top shell snails at USAKA is higher than the current information can confirm.

As discussed more fully in the Environmental Baseline and Cumulative Effects sections, the effects of continued flight testing, coastal development, direct take, and climate change are expected to continue and likely worsen in the future for this species. Although many actions at USAKA beyond what are described in the Environmental Baseline and Cumulative Effects sections are uncertain, we do have expected estimates (worst-case scenarios) for the actions described above in those sections, and we acknowledge that there are other federal actions occurring in the Atoll (previous, ongoing and known future actions) impacting these species. For example, the FE-1, ARRW, and FE-2 testing will remove up to four top shell snails for each project (for a total of up to 12 top shell snails cumulatively). PRD has considered the action's impacts with the other threats incurring on the species, and even with the worst case scenario (loss of individuals due to this action) added to other losses discussed in the Environmental Baseline and Cumulative Effects sections, we do not expect these actions to result in appreciable reduction of the species.

The proposed action is anticipated to result in death of up to nine top shell snails at Illeginni. The affected snails would represent a small fraction of the total number of top shell snails found at Illeginni, and an even smaller proportion of the population across USAKA. In the context of this action, the potential loss of nine top shell snails across the area is not expected to significantly impact reproduction or to impede the recovery of this species across USAKA and the MAC. Therefore, when taken in context with the status of the species, the environmental baseline, cumulative impacts and effects, the proposed action is not likely to eliminate top shell snails at Illeginni, or appreciably reduce the likelihood of their survival and recovery across USAKA including the MAC.

8.3 Giant Clams

As described in the Effects of the Action section, a total of up to 219 giant clams could be harassed, injured, or killed through some combination of exposure to direct payload impact, ejecta, and ground-based shock wave.

As discussed in the Status of Listed Species, the two clam species have been reported at most of the 11 USAKA islets, (nine for *H. hippopus* and six for *T. squamosa*) as well as at nine and 24 respectively of 35 survey sites in the mid-atoll corridor. It is important to recognize that survey data for USAKA is far from complete. Only a small portion of the total reef area around the USAKA islets has been surveyed, and surveys to specifically identify and quantify this species are yet to be done.

As discussed more fully in the Environmental Baseline and Cumulative Effects sections, the effects of continued flight testing, coastal development, direct take, and climate change are expected to continue and likely worsen in the future for this species. Although many actions at USAKA beyond what are described in the Environmental Baseline and Cumulative Effects sections are uncertain, we do have expected estimates (worst-case scenarios) for the actions described above in those sections, and we acknowledge that there are other federal actions occurring in the Atoll (previous, ongoing and known future actions) impacting these species. For example, the FE-1 testing will remove up to 90 giant clams, the ARRW testing will remove up to 90 giant clams, and the FE-2 testing will remove up to 75 giant clams (for a total of up to 255 giant clams cumulatively). PRD has considered the action's impacts with the other threats incurring on the species, and even with the worst-case scenario (loss of individuals due to this action) added to other losses discussed in the Environmental Baseline and Cumulative Effects sections, we do not expect these actions to result in appreciable reduction of the species.

The proposed action is anticipated to result in death of up to 219 (186 *H. hippopus* and 33 *T. squamosa*) at Illeginni. The affected clams would represent a small fraction of the total number of clams found at Illeginni, and an even smaller proportion of the population across USAKA. In the context of this action, the potential loss of giant clams across the area is not expected to significantly impact reproduction or to impede the recovery of this species across USAKA and the mid-atoll corridor. Therefore, when taken in context with the status of the species, the environmental baseline, cumulative impacts and effects, the proposed action is not likely to eliminate giant clams at Illeginni, or appreciably reduce the likelihood of their survival and recovery across USAKA including the mid-atoll corridor.

8.4 Humphead Wrasse

As described in the Effects of the Action section, a total of up to 342 humphead wrasses could be harassed, injured, or killed through some combination of exposure to direct payload impact, ejecta, and ground-based shock wave.

As discussed in the Status of Listed Species section, humphead wrasses are commonly observed at Kwajalein Atoll, and have been observed at 10 of the 11 surveyed islets since 2010. Observations suggest a broad but scattered distribution. It is important to recognize that survey data for USAKA is incomplete. Only a small portion of the total reef area around the USAKA islets have been surveyed, especially in deeper waters where humphead wrasse could live.

As discussed in the Environmental Baseline and Cumulative Effects section, the effects of continued flight testing, coastal development, direct take, and climate change are expected to continue and for climate change in particular expect to worsen in the future. Although many actions at USAKA beyond what are described in the Environmental Baseline and Cumulative Effects sections are uncertain, we do have expected estimates (worst-case scenarios) for the actions described above in those sections, and we acknowledge that there are other federal actions occurring in the Atoll (previous, ongoing and known future actions) impacting these species. For example, the FE-1, ARRW, and FE-2 testing will remove up to 108 humphead wrasse for each project (for a total of up to 324 humphead wrasse cumulatively). PRD has considered the action's impacts with the other threats incurring on the species, and even with the worst-case scenario (loss of individuals due to this action) added to other losses discussed in the Environmental Baseline and Cumulative Effects sections, we do not expect these actions to result in appreciable reduction of the species.

The proposed action is anticipated to result in the injury or death of up to 324 humphead wrasse (300 juveniles and 24 adults) at Illeginni. The affected individuals would represent a small portion of the total number of humphead wrasse found at Illeginni, and an even smaller proportion of the population across USAKA. In the context of this action, the potential loss of humphead wrasses by the action is not expected to significantly impact reproduction or to impede the recovery of this species across USAKA and the MAC. Therefore, when taken in context with the status of the species, the environmental baseline, cumulative impacts and effects, the proposed action is not likely to eliminate humphead wrasses at Illeginni, or appreciably reduce the likelihood of their survival and recovery across USAKA including the MAC.

9 CONCLUSION

After reviewing the current status of UES-protected marine species, the environmental baseline for the action area, the effects of the proposed action, and the cumulative effects, it is our Opinion that the USAF/USASMDC's implementation of the GBSD weapon system testing at USAKA, RMI is not likely to jeopardize the continued existence of any of the UES-protected corals considered in this Opinion, the top shell snail, humphead wrasse, or two species of giant clams. No critical habitat has been designated or proposed for designation for any UES-protected marine species in the BOA or elsewhere in the RMI. Therefore, the proposed action would have no effect on designated or proposed critical habitat in the RMI.

10 INCIDENTAL TAKE STATEMENT

The UES does not specifically describe "take" for a biological opinion. However, under the ESA "take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, collect, or attempt to engage in any such conduct. "Incidental take" is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of Section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the ESA provided that such taking is in compliance with the reasonable and prudent measures and terms and conditions of the Incidental Take Statement (ITS). Although the ESA does not specifically apply to actions taken at USAKA, under section 161 of the Compact and the UES, the ESA provides the basis for determining the level of incidental take, so the ESA definitions will be used for this Opinion.

10.1 Anticipated Amount or Extent of Incidental Take

Based on the analysis in the accompanying Opinion, we conclude that the GBSD flight tests at USAKA would result in the take of seven species of UES consultation corals, top shell snails, humpback wrasse, and two clam species. As described above in the exposure and response analyses, we expect that up to 31,224 colonies of UES consultation corals (as quantified in Table 8, below) could experience complete mortality, up to nine top shell snail, up to 219 clams, and up to 324 humphead wrasse could be killed by the proposed action.

Table 8. Expected take of marine UES consultation species due to GBSD flight tests.

Scientific Name	**Species**	**Colonies or Individuals Affected**
Corals		
Acropora microclados	No Common Name	51
A. polystoma	No Common Name	51
Cyphastrea agassizi	No Common Name	42
Heliopora coerulea	No Common Name	14,049
Pavona venosa	No Common Name	42
Turbinaria reniformis	No Common Name	42
Pocillopora meandrina	Cauliflower coral	16,947
Mollusks		
Tectus niloticus	Top Shell Snail	9
Hippopus hippopus	Giant clam	186
Tridacna squamosa	Giant clam	33
Fish		
Cheilinus undulates	Humphead wrasse	324 (24 adults/300 juveniles)

10.2 Effect of Impact of the Take

In this Opinion, we determined that this level of anticipated take is not likely to result in the jeopardy of any of the UES consultation species expected to be taken by the proposed action.

10.3 Reasonable and Prudent Measures

We believe the following reasonable and prudent measures, as implemented by the terms and conditions, are necessary and appropriate to minimize impacts of the proposed action and monitor levels of incidental take. The measures described below are non-discretionary and must be undertaken in order for the ITS to apply.

1. The USAF/USASMDC shall reduce impacts on UES-protected corals, top shell snails, clams, humphead wrasse and their habitats through the employment of best management practices and conservation measures.
2. The USAF/USASMDC shall record and report all action-related take of UES-consultation species.

10.4 Terms and Conditions

The USAF/USASMDC must comply with the following terms and conditions, which implement the reasonable and prudent measures described above and outline required reporting/monitoring requirements. These terms and conditions are non-discretionary.

1. To meet reasonable and prudent measure 1 above, the USAF/USASMDC shall ensure that their personnel comply fully with the conservation measures identified below.
    a. The USAF/USASMDC shall ensure that all relevant personnel associated with this project are fully briefed on the best management practices and the requirement to adhere to them for the duration of this project.
    b. In the event the payload land impact affects the reef at Illeginni, the USAF/USASMDC shall require its personnel to secure or remove from the water any substrate or coral rubble from the ejecta impact zone that may become mobilized by wave action as soon as possible.
        i. Ejecta greater than six inches in any dimension shall be removed from the water or positioned such that it would not become mobilized by expected wave action, including replacement in the payload crater.
        ii. If possible, coral fragments greater than six inches in any dimension shall be positioned on the reef such that they would not become mobilized by expected wave action, and in a manner that would enhance its survival; away from fine sediments with the majority of the living tissue (polyps) facing up.
        iii. UES consultation coral fragments that cannot be secured in-place should be relocated to suitable habitat where it is not likely to become mobilized.
    c. In the event the payload land impact affects the reef at Illeginni, the USAF/USASMDC shall require its personnel to reduce impacts on top shell snails.
        i. Rescue and reposition any living top shell snails that are buried or trapped by rubble.
        ii. Relocate to suitable habitat, any living top shell snails that are in the path of any heavy equipment that must be used in the marine environment.
    d. In the event the payload land impact affects the reef at Illeginni, the USAF/USASMDC shall require its personnel to reduce impacts on clams.
        i. Rescue and reposition any living clams that are buried or trapped by rubble.
        ii. Relocate to suitable habitat, any living clams that are in the path of any heavy equipment that must be used in the marine environment.

2. To meet reasonable and prudent measure 2 above:
    a. The USAF/USASMDC shall assign appropriately qualified personnel to record all suspected incidences of take of any UES-consultation species.
    b. The USAF/USASMDC shall utilize digital photography to record any UES-consultation species found injured or killed in or near the ocean target areas and/or at Illeginni. As practicable: 1) Photograph all damaged corals and/or other UES-consultation species that may be observed injured or dead; 2) Include a scaling device (such as a ruler) in photographs to aid in the determination of size; and 3) Record the location of the photograph.
    c. In the event the payload impact affects the reef at Illeginni, the USAF/USASMDC shall require its personnel to survey the ejecta field for impacted corals, top shell snails, and clams. Also be mindful for any other UES-consultation species that may have been affected.
    d. Within 60 days of completing post-test clean-up and restoration, provide photographs and records to the USAKA environmental office. USAKA and our biologists will review the photographs and records to identify the organisms to the lowest taxonomic level accurately possible to assess impacts on consultation species.
    e. Within 6 months of completion of the action, USAKA will provide a report to us. The report shall identify: 1) The flight test and date; 2) The target area; 3) The results of the pre- and post-flight surveys; 4) The identity and quantity of affected resources (include photographs and videos as applicable); and 5) The disposition of any relocation efforts.

11 CONSERVATION RECOMMENDATIONS

The following conservation recommendations are discretionary agency activities provided to minimize or avoid adverse effects of a proposed action on UES-protected marine species or critical habitat, to help implement recovery plans, or develop information.

1. We recommend that the USAF/USASMDC continue to work with NMFS staff to conduct additional marine surveys around Illeginni Islet to develop a comprehensive understanding of the distribution and abundance of species that are there.
2. We recommend that the USAF/USASMDC consider constructing a berm, artificial Hesco Bastion (“Concertainer”), or Bremer wall, around the perimeter of the island above the beach line (see start of grass line in Figure 2 for example) at the impact site in order to reduce the amount of potential ejecta material which can enter the ocean from an impacting projectile. We understand that depending on impact characteristics ejecta may arch at a higher angle than a berm’s height. Additionally, consultation may be required with the USFWS for landbased activities. However, we believe it should be considered. This would reduce the risk to UES/ESA-listed species in the nearshore, allow for more precise definition of the target, and aid in the recovery of munition materials after impact.
3. We recommend the USAF/USASMDC equip USAG-KA personnel with metal detectors for recovery of projectile materials in the nearshore environment, if not already doing so. Furthermore, we recommend the USAF/USASMDC attempt to quantify the amount of recovered materials to determine the amount of tungsten that remains in the nearby environment.

4. We recommend that the USAF/USASMDC continue to work with NMFS staff to conduct marine surveys at additional sites around all of the USAKA islets and in the mid-atoll corridor to develop a more comprehensive understanding of the distribution and abundance of species and habitats at USAKA.
5. We recommend that the USAKA develop capacity and procedures for responding to marine mammal and turtle strandings.
    a. Acquire required permits and training to perform necropsies and/or to take and transport tissue samples.
    b. Develop professional relations with qualified federal agencies and universities to capitalize on samples and information gained at USAKA.
    c. Develop mechanisms to collect and disseminate the information.

11.1 Reinitiation Notice

This concludes formal consultation on the implementation of the GBSD program at the USAKA, RMI. Reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained or is authorized by law, and if:

1. The amount or extent of anticipated incidental take is exceeded;
2. New information reveals that the action may affect UES-protected marine species or critical habitat in a manner or to an extent not considered in this Opinion;
3. The action is subsequently modified in a manner that may affect UES-protected marine species or critical habitat to an extent, or in a manner not considered in this Opinion; or
4. A new species is listed or critical habitat designated that may be affected by the action.

12 DATA QUALITY ACT DOCUMENTATION

The Data Quality Act (DQA) specifies three components contributing to the quality of a document. They are utility, integrity, and objectivity. This section of the Opinion addresses these DQA components, documents compliance with the DQA, and certifies that this Supplement has undergone pre-dissemination review.

12.1 Utility

Utility principally refers to ensuring that the information contained in this consultation is helpful, serviceable, and beneficial to the intended users. The intended user of this Opinion is the USAF/USASMDC. Other interested users could include the citizens of RMI, USFWS, and NOAA. Individual copies of this Opinion were provided to the USAF/USASMDC. The format and naming adheres to conventional standards for style.

12.2 Integrity

This consultation was completed on a computer system managed by NMFS in accordance with relevant information technology security policies and standards set out in Appendix III, 'Security of Automated Information Resources,' Office of Management and Budget Circular A-130; the Computer Security Act; and the Government Information Security Reform Act.

12.3 Objectivity

Information Product Category: Natural Resource Plan

Standards: This consultation and supporting documents are clear, concise, complete, and unbiased; and were developed using commonly accepted scientific research methods. They adhere to published standards including the NMFS ESA Consultation Handbook, ESA regulations, 50 CFR 402.01 et seq.

Best Available Information: This consultation and supporting documents use the best available information, as referenced in the References section. The analyses in this Opinion contain more background on information sources and quality.

Referencing: All supporting materials, information, data and analyses are properly referenced, consistent with standard scientific referencing style.

Review Process: This consultation was drafted by NMFS staff with UES and ESA training and reviewed in accordance with Pacific Islands Region ESA quality control and assurance processes.

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