Formal Consultation under the
Environmental Standards for United States Army Kwajalein Atoll
Activities in the Republic of the Marshall Islands

Biological Opinion

And
Informal Consultation under Section 7 of the Endangered Species Act

Action Agencies:	Department of the Air Force, Life Cycle Management Center Department of the Army, U.S. Army Space and Missile Defense Command/Army Forces Strategic Command (USASMDC/ARSTRAT) – Huntsville AL
	Activity: Air-launched Rapid Response Weapon Flight Tests
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Approved By:	______________________________________
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Acronyms

ARRW	Air-launched Rapid Response Weapon
ARSTRAT	Army Forces Strategic Command, US Army
BA	Biological Assessment
BOA	Broad Ocean Area
CFR	Code of Federal Regulations
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
dB	Decibels
DPS	Distinct Population Segment
DQA	Data Quality Act
ESA	Endangered Species Act
FR	Federal Register
ft	Foot or Feet
kg	Kilogram
km	Kilometer
LCU	Landing Craft Utility
m	Meter
MATSS	Mobile Area Target Support System
MMPA	Marine Mammal Protection Act
NCN	No Common Name
NEPA	National Environmental Policy Act
NLAA	Not Likely to Adversely Affect
nm	Nautical Miles
NMFS	National Marine Fisheries Service (aka NOAA Fisheries)
NOAA	National Oceanic and Atmospheric Administration
PIRO	Pacific Islands Regional Office
PTS	Permanent Threshold Shift
RMI	Republic of the Marshall Islands
RMS	Root Mean Squared
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 Threshold Shift
UES	USAKA Environmental Standards
USAF	U.S. Air Force
USAKA	U.S. Army Kwajalein Atoll
USAG-KA	US Army Garrison - Kwajalein Atoll
USASMDC	Space and Missile Defense Command, US Army
FWS	US Fish and Wildlife Service

1 Introduction

The Republic of the Marshall Islands (RMI) has agreed to allow the U.S. Government to use certain areas within the RMI, including eleven islets at Kwajalein Atoll that are administered by the U.S. Army Kwajalein Atoll (USAKA). The relationship between the U.S. and RMI Governments is governed by the Compact of Free Association (Compact), as Amended in 2003 (48 U.S.C. 1921). 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 Endangered Species Act (ESA) does not apply at USAKA. 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 U.S. 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.

The Endangered Species Act (ESA) would apply for the portions of the action that would take place in and over United States territory and international waters, but not for the portions of the action that would take place within the RMI. Those portions of the action that will occur in the RMI will be considered for consistency with the UES.

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 it authorizes, funds, or carries 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" an ESA-listed species, that agency is required to consult formally with the National Marine Fisheries Service (NMFS; for marine species or their designated critical habitat) or the U.S. Fish and Wildlife Service (FWS; for terrestrial and freshwater species or their designated critical habitat). Federal agencies are exempt from this formal consultation requirement if they have concluded that an action "may affect, but is not likely to adversely affect" ESA-listed 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. Army Space and Missile Defense Command/Army Forces Strategic Command (USASMDC/ARSTRAT) is the participating agency, and the U.S. Air Force (USAF) is a cooperating 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/ARSTRAT 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 US 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. Additionally, no designated critical habitat exists in the broad ocean area (BOA) for any species considered in this Opinion.

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 our Opinion of the effects on marine species protected under the ESA and the UES that may result from the ARRW flight test at the Reagan Test Site (RTS) at Kwajalein Atoll. This Opinion is based on the review of: the USASMDC/ARSTRAT January 29, 2019, Biological Assessment (BA), and revised June 11, 2019 BA for the proposed action; recovery plans for U.S. Pacific populations of ESA-listed marine mammals and sea turtles; 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).

2 Consultation History

On February 12, 2019, we received from USASMDC/ARSTRAT, on behalf of the USAF, a consultation request and BA for the proposed action, stating that they had determined that the ARRW flight test may affect 61 marine ESA and/or UES consultation species, and requested consultation for those species.

After discussion on action areas and probabilities of interactions in the broad ocean area (BOA), the USASMDC/ARSTRAT revised their BA and their effect calls on primarily pelagic species. We received a revised BA from USASMDC/ARSTRAT on June 11, 2019. The USASMDC/ARSTRAT determined no effect for all species (except four bird species) to all stressors under consideration in the BOA (See left half of Table ES-1; USASMDC/ARSTRAT 2019). They further determined that the project is likely to adversely affect 11 UES-consultation species in the vicinity of Illeginni Islet which are listed in Table 1. Finally, USASMDC/ARSTRAT determined 34 species in the vicinity of Illeginni Islet are not likely to adversely affected and are listed in Table 2.

While NMFS has no obligation to review or concur on No Effect calls. In Table ES-1, No Effect determinations were documented for 11 cetacean species (see those in Table 2) in relation specifically to sound stressors in the vicinity of Illeginni Islet. However, a rather extensive analysis is provided in the BA and the text identifies sound stressors would have discountable effects (ex: see page 132). Therefore, in our analysis of this proposed project, NMFS concludes sound stressors may affect, but are not likely to adversely affect these various species in the vicinity of Illeginni Islet.

Additionally, while No Effect calls were determined for all species in the BOA for all stressors according to Table ES-1; analysis provided in the BA for effects from sound stressors (i.e. sonic booms) and direct contact from missile components concluded insignificant or discountable determinations (ex: see page 125 or 127 of the BA). Meaning these stressors may affect, but are not likely to adversely affect the species under consideration. Specifically, all cetaceans, sea turtles, oceanic white tip sharks, bigeye thresher sharks, giant manta ray, and all pinnipeds. NMFS agrees that Hawaiian monk seal, scalloped hammerhead shark, reef manta ray, humphead wrasse, all corals, and all mollusks under consideration do not or are not likely to occur in the BOA and, therefore, will not be affected by any elevated sound levels or be subjected to impact from missile components in the BOA. NMFS documents it's determinations in the subsequent analysis of the proposed action (See *Species and Critical Habitats Not Likely to be Adversely Affected*).

Furthermore, in the BA the USASMDC/ARSTRAT determined that no effect would occur to Pacific Bluefin tuna in the BOA, and presence of the species was unknown at the islet (see Table ES-1 in the BA). However, in the previous paragraph a Not Likely to Adversely Affect determination was made for the species. Considering the species ecology, distribution, depth range preferences of the species and the proposed action, and migratory nature of the species, NMFS would not expect Pacific bluefin tuna to be present in the nearshore (>10 ft depth) area where missiles or ejecta could strike, agreeing with the no effect call made by USASMDC/ARSTRAT in Table ES-1 of the BA, and will not be considered further.

Lastly, any bird species identified in the BA will not be discussed further as the USFWS has jurisdiction over those species. NMFS therefore expects USFWS to conduct an effects analysis for those species during their respective consultation proceedings.

Table 1. Marine consultation species likely to be adversely affected by the proposed action.

Species	CITES Appendix	RMI-protected only
Cheilinus undulatus, Humphead Wrasse	II	
Acropora microclados, No Common Name (NCN)	II	
A. polystoma, NCN	II	
Cyphastrea agassizi, NCN	II	
Heliopora coerulea, NCN	II	
Pavona venosa, NCN	II	
Pocillopora meandrina, Cauliflower coral	II	
Turbinaria reniformis, NCN	II	
Tectus niloticus, Top shell snail		X
Hippopus hippopus, Giant clam	II	
Tridacna squamosa, Giant clam	II	

Table 2. Marine consultation species not likely to be adversely affected by the proposed action as identified by USASMDC/ARSTRAT.

Species	ESA	CITES Appendix	RMI-protected only
Balaenoptera acutorostrata, minke whale		I	
B. edeni, Bryde's whale		I	
Delphinus delphis, Short-beaked common dolphin		II	
Globicephala macrorhynchus, Short-finned pilot whale		II	
Orcinus orca, Killer whale		II	
Peponocephala electra, Melon-headed whale		II	
Physeter microcephalus, Sperm whale	Endangered	II	
Stenella attenuata, Pantropical spotted dolphin		II	
S. coeruleoalba, Striped dolpin		II	
S. longirostris, Spinner dolphin		II	
Tursiops truncates, Bottlenose dolphin		II	
Chelonia mydas, Green sea turtle	Endangered[1]	I	
Eretmochelys imbricata, Hawksbill sea turtle	Endangered	I	
Manta alfredi, Reef manta ray		II	
M. birostris, Giant manta ray	Threatened	II	
Sphyrna lewini, Scalloped hammerhead shark	Threatened[2]	II	
Acanthastrea brevis, NCN		II	
Acropora aculeus, NCN		II	
A. aspera, NCN		II	
A. dendrum, NCN		II	
A. listeri, NCN		II	
A. speciosa, NCN	Threatened	II	
A. tenella, NCN	Threatened	II	

Species	ESA	CITES Appendix	RMI-protected only
A. vaughani, NCN		II	
Alveopora verrilliana, NCN		II	
Leptoseris incrustans, NCN		II	
Montipora caliculata, NCN		II	
Pavona cactus, NCN		II	
P. decussata, NCN		II	
Tubinaria mesenterina, NCN		II	
T. stellulata, NCN		II	
Pinctada margarifera, Black-lip pearl oyster			X
Tridacna gigas, Giant clam		II	
Larval fish, coral, and mollusks	Threatened[3]	II	

[1] – Green sea turtles in this action area are from the Central West Pacific DPS, which is listed as endangered under the ESA.
[2] – Scalloped hammerhead sharks in this action area are from the Indo-West Pacific DPS, which is listed as threatened under the ESA.
[3] – Larvae pertaining to species under consideration in this Opinion; highest category documented for the purposes of this table (Ex: *A. speciosa*).

3 Description of the Proposed Action and Action Area

The proposed action is described in detail in the USASMDC/ARSTRAT BA. The purpose of the Proposed Action is to test the performance and demonstrate the capabilities of the ARRW system and collect data on the payload impact.

The USAF is proposing to conduct four tests of their Air-launched Rapid Response Weapon (ARRW) in 2021 and 2022. The ARRW system consists of a solid-rocket motor booster, a protective shroud, a payload adapter assembly, a booster glider separation system, and the experimental payload. The ARRW will be carried externally on B-52 aircraft and released in-flight. The takeoff and flight of the B-52 are part of existing USAF programs and the potential effects of the B-52 takeoff and flight have been analyzed separately in the Environmental Assessment (EA) for Increasing Routine Flightline Activities, Edwards Air Force Base, California (95th Air Base Wing 2009). The USAF will launch a missile from an aircraft somewhere over the Pacific Ocean, where it will travel toward and hit its target on Illeginni Islet at Kwajalein. As the missile travels toward Kwajalein, boosters and other components of the missile will drop off and fall into areas labeled as the broad ocean area (BOA) pictured in figure 1. Each components are expected to drop off into the ocean hundreds of miles apart. The payload will land at terminal end at Illeginni Islet. The intended targets will be located on a 450-foot wide strip of land between the lagoon and the open ocean. Both sides are bordered with coral reefs nearshore. The USAF will also place sensors on land and in water to collect data of the flight and impact.

After impact, the USAF will collect all ejecta and debris from the payload for testing and analysis. This may include manual removal within the intertidal or subtidal zones. The USAF will also use heavy equipment and other methods to fill the crater and regrade the ground impacted by the payload.

The booster is 417 centimeters (cm) (164 inches [in]) long with a diameter of 66 cm (26 in) which includes the payload adapter assembly. The shroud is 173 cm (68 in) long with a diameter of 66 cm (26 in). The amount of propellant in the booster is approximately 1,600 kilograms (kg; 3,600 pounds [lb]). Approximately 79 kg (175 lb) of tungsten will be contained in the payload. The ARRW system will also have approximately 1,600 kg (3,600 lb) of aluminized Hydroxyl Terminated Polybutadiene, a communications systems, 28-volt and 150-volt batteries, and electro-explosive devices (to detach parts of the missile). The components of the booster and shroud are generally metal and high-density plastic which are expected to sink to the bottom of the ocean after entry.

Launch Vehicle Description

Table 3 details the launch vehicle characteristics and Table 4 describes the payload system characteristics. Up to 79 kg or (175 lbs) of tungsten will be contained in the payload. A nose fairing covers the payload until separation from the third stage motor. This nose fairing is approximately 3.12 m (100 in) long composed with a diameter of 1.37 m (54 in) and then tapering to a 10.16 cm (4 in) diameter at the nose. The nose fairing is a single piece but there are two clamshell extensions on the bottom 61 cm (24 in) in length that separate into two symmetric halves.

Table 3. Launch Vehicle Characteristics

Major components	Total weight not to exceed 2,300 kg (5,000 lb); 589 cm (232 in) length and 66 cm (26 in) diameter; carbon phenolic with metal shell, graphite, and approximately 79 kg (175 lb) tungsten
Communications	MIL-STD-1760 communications between host aircraft and ARRW, S-Band Telemetry
Power	MIL-STD-1760 power source, 28-volt battery, 150-volt battery
Propulsion/Propellant	Approximately 1,600 kg (3,600 lb) of aluminized Hydroxyl Terminated Polybutadiene
Other	Small Class C (1.4) electro-explosive devices

Table 4. Payload System Characteristics

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

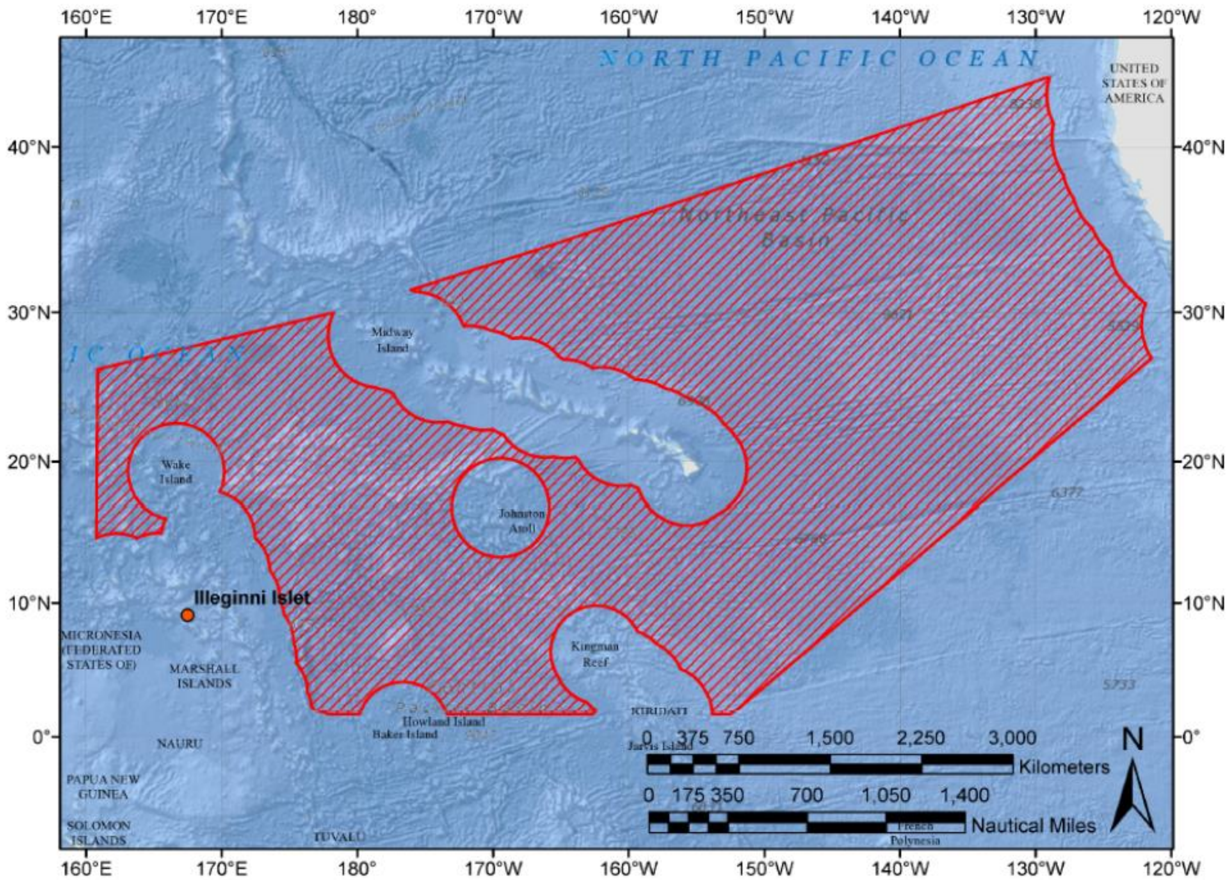

Figure 1. The Broad Ocean Area portion of the action area.

Upon reaching the terminal end of the flight, the payload would impact on the non-forested northwestern end of Illeginni Islet (**Error! Reference source not found.**2). A crater would form as a result of this impact and leave debris containing less than 454 kg (1,000 lbs) of tungsten. Targeted areas for the payload will be selected to minimize impacts to reefs and identified wildlife habitats. A coral reef or shallow water impact at Illeginni is not part of the proposed action, would be unintentional, and is unlikely (KFS 2019).

Figure 2. Potential Land Impact Area on Illeginni Islet, Kwajalein Atoll.

Sensor Coverage in the BOA: The flight path would initiate from air-drop of the ARRW from a B-52 at some location in the BOA of the Action Area and continue to USAKA in the RMI. Various sea-based sensors would be used during the ARRW test flight. The sensors may include:

- the Missile Defense Agency Pacific Collector;
- the Mobile Aerial Target Support System (MATSS); and
- the Kwajalein Mobile Range Safety System onboard the U.S. Motor Vessel Worthy.

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

Sensor Coverage at USAKA: The USAF may deploy small portable radars on Illeginni Islet to gather information on the payload during flight test operations. If radar units are used, they would fit within a 61 cm by 38 cm by 15 cm (24 in by 15 in by 6 in) box, would be placed within the impact area, and may be destroyed by payload impact. If deployed, radars would be powered by automobile batteries or on-shore generator power.

In addition to land-based radars and sensor vessel support, self-stationing rafts may be placed in the lagoon and ocean waters near Illeginni Islet. The specifications of these rafts are not known at this time; however, for past fight tests at Illeginni Islet, rafts have been equipped with battery-powered electric motors for propulsion to maintain position in the water. Two types of rafts may be used, hydrophone rafts and camera rafts. Hydrophone rafts are equipped with hydrophones that are deployed off the back of the raft and hang in the water at a depth of approximately 3.7 m (12 ft). Camera rafts are equipped with stabilized cameras as well as hydrophones as described above. If rafts are used, rafts would be deployed before the flight test using one or two range landing craft utility (LCU) vessels. Rafts would be deployed in waters at least 4 m (13 ft) deep to avoid contact with the substrate and/or coral colonies. Sensors on the rafts would collect data during the payload's descent until impact.

Pre-Flight Preparation at Illeginni Islet: Pre-flight preparation activities at Illeginni Islet would include several vessel round-trips (likely with the U.S. Army Landing Craft, Great Bridge) and helicopter trips for equipment and personnel transport. There would be increased human activity on Illeginni Islet that would involve personnel presence over a 2 to 3-month period. Heavy equipment placement and use on Illeginni Islet would occur at times and be limited to transport on existing roads from the harbor to the impact area as well as in the impact area itself.

Flight Operations: After air-drop from the B-52 aircraft over the Pacific Ocean, the solid rocket motor will ignite for ARRW flight towards USAKA. The ARRW flight over the BOA would be monitored by land, sea and/or air-based sensors deployed prior to each flight test. Following rocket motor burnout, the spent booster (with the PAA attached) and the shroud will separate from the payload and splashdown into the BOA of the Action Area. The mission planning process would avoid to the maximum extent possible all potential risks to environmentally significant areas. All actual splashdown areas would be determined based on range safety requirements and chosen as part of the mission analysis process.

If the ARRW system were to deviate from its course or should other problems occur during flight that might jeopardize public safety, the onboard flight termination system (FTS) would be activated. This action would initiate a destruct charge causing the ARRW system to terminate flight and fall towards the ocean. The FTS would be designed to prevent any debris from falling into any protected area. No human inhabited land areas would be subject to unacceptable risks of falling debris. The ARRW flight path would avoid inhabited areas, as per U.S. range operation standards and practices.

The payload would fly toward pre-designated target sites at Illeginni Islet. Upon reaching the terminal end of the flight, the payload would impact on the non-forested northwestern end of Illeginni Islet (Figure 2). A crater would form as a result of this impact and leave debris containing approximately 79 kg (175 lb) of tungsten. Targeted areas for the payload would be selected to minimize impacts to reefs and sensitive habitats. The impact point on Illeginni Islet would be west of the forest tree line to avoid affecting sensitive bird habitat (Figure 2). A coral reef or shallow water impact at Illeginni is not part of the Proposed Action, would be unintentional, and is unlikely.

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

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

If an inadvertent impact occurs on the reef, reef flat, or in shallow waters less than 3 m (10 ft) deep, an inspection by project personnel would occur within 24 hours. Representatives from the NMFS and FWS would also be invited to inspect the site as soon as practical after the test. The inspectors would be invited to assess any damage to coral and other natural and biological resources and, in coordination with SSP, USAG-KA and RTS representatives, decide on any mitigation measures that may be required. In general, payload recovery operations would not be attempted in deeper waters on the ocean side of the Atoll.

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

3.1 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, 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 ARRW test 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 this action 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.

3.2 Action Area

The location where the missile will be launched will not be revealed but will occur in the BOA. The BOA extends across the Pacific Ocean to the west-southwest, along a relatively narrow band of ocean directly under the flight path of the missiles (see Figure 1). Boosters and shrouds are expected to fall somewhere in the BOA where it may affect any animals that could be nearby. The BOA defines the action area. The USAF proposes to conduct up to four flight tests, resulting in sixteen entries into the water within the BOA within the two-year period. The action will not affect the entire action area, rather it will affect eight independent locations within the BOA during each splash down. Any animal within those independent locations only during each splash down will be affected by this action. The action area also includes the area of and around Kwajalein Atoll, RMI where the payload would impact the target areas, as well as the areas immediately around support vessels and sensor rafts used to monitor the payload impacts, and the down-current extent of any plumes that may result from discharges of wastes or toxic chemicals such as fuels and/or lubricants associated with the machinery used for this activity.

4 Species and Critical Habitats Not Likely to be Adversely Affected

As explained above in Section 1, USASMDC/ARSTRAT determined that the proposed action is not likely to adversely affect (NLAA) the 34 consultation species listed in Table 2, and would have no effect on critical habitats designated under the ESA and/or the UES. 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 USASMDC/ARSTRAT's determination. As previously discussed in the *Consultation History*, NMFS believes effects to pelagic species under consideration in the BOA (cetaceans, sea turtles, oceanic white tip sharks, bigeye thresher sharks, giant manta ray, and pinnipeds) may affect but are NLAA. 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). As described in Section 2, test flights have 3 distinct phases: Launch; Over-Ocean Flight; and Terminal Flight and Impact in the RMI. Each phase has potential stressors, listed below, that are based on what the missile is doing, and on activities done to support the test.

Over-Ocean Flight: The potential stressors during over-ocean flight are:

a. Exposure to elevated noise levels;
b. Impact by falling missile components; and
c. Exposure to hazardous materials.

Terminal Flight and Reentry Vehicles (RVs) Impact in the RMI: The potential stressors during terminal flight, payload impact, and preparation and restoration work at Kwajalein Atoll are:

a. Exposure to elevated noise levels;
b. Impact by falling missile components;
c. Exposure to hazardous materials;
d. Disturbance from human activity and equipment operation; and
e. Collision with vessels.

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 the aircraft launch and Kwajalein Atoll, 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 spent rocket motors' impact the ocean's surface (splash-down). 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 USASMDC/ARSTRAT 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). Root mean square (RMS) is the quadratic mean sound pressure over the duration of a single impulse. RMS is used to account for both positive and negative values so that they may be accounted for in the summation of pressure levels (Hastings and Popper 2005). This measurement is often used in the context of discussing behavioral effects, in part because behavioral effects, which often result from auditory cues, may be better expressed through averaged units rather than by peak pressures. For brevity, all further references to sound level assume dB_{rms} re 1 µPa, unless specified differently.

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 (Finneran and Jenkins 2012; Popper et al. 2014; NMFS 2018).

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)

Hearing Group	TTS peak pressure threshold (SPL_{peak})	Weighted TTS onset threshold (SEL_{CUM})	Estimated threshold for behavioral changes
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 2018). 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.

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 (NASA 2014). Exposure to sonic booms would have insignificant effects on any of the species considered in this consultation. The ARRW missile may generate sonic booms from shortly after launch, along the entire ARRW fight path in the BOA, and at impact at or near Illeginni. Sound attenuates with distance from the source due to spreading and other factors. Similarly, the greater the distance either side of the centerline of the flight path, the quieter the sonic boom. Therefore, the sound intensity would be loudest directly below the missile when the component is closest to the surface. Additionally, Laney and Cavanagh (2000) report that sound waves arriving at the air/water interface at an angle less steep than 13.3º from of the vertical will not normally propagate into water. This means that within the footprint of the sonic boom, only those marine animals within 13.3º of directly below the source could be expected to hear the sonic boom. Sounds originating in air, even intense ones like sonic booms transfer poorly into water, and most of its energy would refract at the surface or absorb in waves or natural surface disturbance at the surface. Once in the water, the sounds of a sonic boom would attenuate with distance. [For this project, Kahle et al. (2017) estimated sound transfer from air to water using a model absent all atmospheric variables that would increase refraction, absorption, and dissipation. The loudest

sounds were assumed to be near launch (145 dB re: 1 µPa) and at impact site (175 dB).] Considering the short (few seconds) duration of the exposure, as noted below, neither are loud or long enough to cause TTS in animals of any of the hearing groups.

Using a model absent most variables that would reduce spreading, (Kahle et al. 2017) predicted the sonic boom footprint of sounds ≥ 160 dB to cover at most a 20.9 square mile radius, and 130.5 square mile radius for sounds ≥ 150 dB. The duration of a sonic boom at any given point within the footprint would be about 0.27 seconds.

In summary, at its loudest (175 dB), an in-water sonic boom exceeds no thresholds for injury to any of the species considered in this consultation, and it is well below the new proposed threshold for the onset of temporary hearing impacts for all hearing groups. Large areas were estimated to be affected by sounds high enough to cause behavioral responses for turtles and fish. However, the models did not account for refraction at the surface, wind or other atmospheric factors like wind and moisture that would dissipate the spreading; it will actually be a much smaller area, as would the corresponding estimate of animals affected by the sonic boom. Those factors would also significantly reduce the intensity of the noise in the water column where most of the UES consultation species spend the majority of their time. NMFS therefore concludes and agrees with the action agencies analysis, that sonic booms created from this proposed action's four test flights to be insignificant for all species under consideration.

Splash-down of Missile Components:
Elevated SPLs would occur in the ocean as the spent booster and shroud impact the ocean's surface in the BOA. SPLs of component splash-down in ocean water depends on the component size, shape, weight, velocity, and trajectory, as well as on-air and water conditions. Three spent rocket motors and a nose fairing will fall into the BOA during each flight. Therefore, a total of 16 components for all four test flights are expected to impact the BOA. The motors are the only components of sufficient size and velocity to create significant noise levels on splash-down. The noise generated by the splash-down will be heard by every hearing group, some even up to a few miles away. The USASMDC/ARSTRAT predicted the impulsive noises created by the splash based on the size of the components, listed in

Table **6**.

Table 6. Stage Impact Contact Areas and Estimated Peak Sound Pressure Levels for ARRW Components.

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

Of the three motors, the first stage is the largest and the one expected to make the most noise on impact; a brief (less than one second) impulse of 218 dB @ 1m (Kahle et al. 2017). All four objects would fall into deep open ocean waters in the BOA.

The payload is expected to impact land at Illeginni Islet. However, cetaceans, sea turtles, adult scalloped hammerhead sharks, oceanic white tip sharks, bigeye thresher sharks, rays, and pelagic fish may be affected by this stressor in the BOA where component parts may splash down.

As sounds dissipate with distance, they get less intense and are less capable of producing injury and behavioral responses. Assuming spherical spreading, the range to the hearing groups' TTS isopleths around each splash-down are listed in **Error! Reference source not found.**6. Since exposure to sounds that could cause TTS would be harmful, we evaluated the probability of an exposure to UES consultation species. The best information available to describe the abundance and distribution of open ocean species considered in this consultation, supports the understanding that these animals are widely scattered, and their densities are very low in the open ocean areas where the motors would splash-down. We know of no information to suggest that the splash-down zones are in areas of any significance that would cause any congregations of these species.

Because the area of influence for TTS is within feet of the missile components' impact with the surface, the splash-downs will create an acoustic area of effect little or no greater than that of direct contact. As such, the probability of exposure is the same as a direct contact. The USASMDC/ARSTRAT compared marine mammal density information from Hawaii, and sea turtle density information from Guam, against the expected range of effect around falling missile components to estimate the probability of effect. Their modeling suggests that the probability of exposing marine mammals to a TTS-level exposure for a test flight would be between 1 in 261,327 chance for the most common and sensitive species (Hanser et al. 2013). This is likely an overestimate because the model assumes animals are at the surface during splashdown (where they spend a small percentage of the time), and those spreading calculations did not include weighting factors used in our evaluations, which reduces the zone of influence. Based on the low annual number of splash-downs, their wide spacing, their small area of effect (< 100 meters), and the expected low densities of the consultation species in the affected areas, we believe that the risk of exposure to splash-down acoustic effects in the open ocean would be highly unlikely and therefore discountable for all species under consideration.

Sounds Caused by Payload Impact

The USASMDC/ARSTRAT believes it would be highly unlikely for the payload to miss the target and impact the nearby ocean. However, if a payload were to impact in the ocean south of Illeginni; sea turtles, scalloped hammerhead sharks, oceanic white tip sharks, bigeye thresher sharks, manta rays, and humphead wrasse along the outer edge of the fringing reef may be exposed to a brief pulse of sound from air or underground. The USASMDC/ARSTRAT recorded similar payload strikes at Illeginni that produced sounds at a level of 140 dB re: 20 µPa 18 m from the source. Using backtracking, the measurements corresponds to a source level of 165 dB, and loosely corresponds to underwater sounds at 191 dB. This is likely an overestimate, because the model did not account for sound refraction, absorption, and other dissipation which happens in natural environments. By the time the sound reaches water, it will likely be less than 191 dB.

The sound at payload impact will be too low to cause TTS. 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, NMFS concludes the exposure is expected to have insignificant effects. 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. Based on the best available information, exposure to splash-down noise is expected to have insignificant effects for all species considered in this consultation.

Equipment Recovery Actions:
The USASMDC/ARSTRAT will use vessels of varying size to install and retrieve equipment in water to gather data and remove debris. Animals in the Illeginni area are likely to be exposed to sounds from vessels. 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. 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. Therefore, NMFS concludes acoustic effects from equipment recovery actions after the payloads impact will have insignificant effects to all species under consideration.

In conclusion, NMFS believes the acoustic stressors created by sonic booms, payload impact, and equipment recovery actions after impact, will have insignificant effects to all species under consideration. Furthermore, acoustic effects to all species under consideration from splash down of the components in the BOA are expected to be highly unlikely and therefore discountable.

<u>b. Impact by falling missile components</u>:
For the reasons discussed below, it is discountable that any of the species considered in this consultation would be hit by falling missile components, 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 2 would be hit by payload or ejecta, or be significantly affected by concussive forces during the four planned payload strikes on Illeginni Islet. However, the payload strike on Illeginni Islet may adversely affect the species identified in Table 1. Therefore, the potential effects of this stressor on those species are considered below in the effects of the action section (Section 4).

Direct Contact – BOA effects
The Proposed Action will result in spent rocket motors and nose fairings splashing down into the BOA as well as impact of the payload on land at Illeginni Islet. These falling components will directly contact aquatic and/or terrestrial habitats and have the potential to directly contact consultation species. Specifically, cetaceans, sea turtles, scalloped hammerhead sharks, oceanic white tip sharks, bigeye thresher sharks, rays, and pelagic fish.

Three spent rocket motors, and various smaller/lighter missile components would fall into the ocean during each flight. To be struck by a missile component, an animal would have to be at, or very close to the surface, and directly under the component when it hits. The first stage motor is about 15 ft (4.6 m) long, 4.5 ft (1.37 m) in diameter, and is the largest component (KFS 2019). The second stage motor is 7.4 ft (2.26 m) long with a diameter of 4.5 ft (1.37 m) and the third stage motor is 4.3 ft (1.32 m) long with a diameter of 4.5 ft (1.37 m). Direct contact areas for these individual components are listed in

Table **6** and total approximately 61 m^2 (189 ft^2).

If a spent rocket motor or other ARRW component were to strike a cetacean, sea turtle, or fish near the water surface, the animal would most likely be killed or injured. Based on the above discussed affected areas, and the best available species density information, chances of direct contact to cetaceans and sea turtles in the BOA were calculated. Calculations are based on methodology in the Mariana Islands Training and Testing Activities Final EIS (Appendix G in US Navy 2015a) and the Hawaii-Southern California Training and Testing EIS (Appendix G in US Navy 2013).

A probability of direct contact and total number of exposures by falling components in the BOA were calculated for each marine mammal species and for a sea turtle guild for each ARRW component based on component characteristics and animal density in the Action Area (KFS 2019). The probability analysis is based on probability theory and modified Venn diagrams with rectangular “footprint” areas for the individual animals and the component impact footprints within the *Action Area*. Sea turtles were combined into a “sea turtle guild” for analyses due to the lack of species-specific occurrence data (Hanser et al. 2013). This sea turtle guild is composed of primarily green and hawksbill turtles as they account for nearly all sightings; however, in theory, the guild also encompasses leatherback, olive ridley, and loggerhead turtles (Hanser et al. 2013; KFS 2019). These analyses assume that all animals would be at or near the surface 100 percent of the time and that the animals are stationary. While these assumptions do not account for animals that spend the majority of time underwater or for any animal movement or potential avoidance to proposed activities, these assumptions should lead to a conservative estimate of direct contact effect on listed species.

Their modeling suggests that the probability of exposing marine mammals in the BOA to direct impact or injurious concussive force for each test flight would be between 1 in 117,000 and 1 in 14,700,000 depending on the species. The probability of exposing sea turtles in the BOA is 1 in 710,000 (Hanser et al. 2013). No density information is available for scalloped hammerhead sharks, bigeye thresher sharks, oceanic white tip sharks, bluefin tuna, humphead wrasse, and the reef or giant manta ray but their densities are believed to be low. Based on that and the expectation that they would be well below the surface most of the time, we believe that the probability of their exposure to direct impact or injurious concussive force would be as low or lower than those described above. USASMDC/ARSTRAT determined that the action will have no effect on all species in the BOA because the probability of interaction is extremely low. However, as previously discussed NFMS believes this analysis shows affects may occur which are not likely to adversely affect all species under consideration which may occur in the BOA (cetaceans, sea turtles, scalloped hammerhead sharks, oceanic white tip sharks, bigeye thresher sharks, rays, and pelagic fish) as they are highly unlikely and therefore discountable.

Direct Contact – Impact Zone Effects

A shoreline payload impact is not planned or expected, however, there is a chance that this will occur or that debris or ejecta from an impact further inland will affect sea turtle nesting habitat near the shoreline, as debris and ejecta may extend out 91 m (300 ft) from the point of impact. Payload component contact with the land may result in cratering and ejecta radiating out from the point of impact. While direct estimates for cratering and ejecta field size are not available for the proposed payload, cratering and ejecta are expected to be less than those of MMIII reentry vehicles. Therefore, MMII estimates of cratering and shock waves (USAFGSC and USASMDC/ARSTRAT 2015) are used as a maximum bounding case for the Proposed Action.

Of the species identified in Table 2, only green and hawksbill sea turtles, may occur in the nearshore areas adjacent to the potential impact site at Illeginni Islet and would be the only two species potentially affected by direct contact of debris or ejecta caused by the payload. 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 direct contact of debris from the payload impact on Illeginni Islet.

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

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

NMFS shares jurisdiction for all listed sea turtle species under the ESA with USFWS. We therefore expect effects from the action to sea turtles on land, and their nests, to be covered by the USFWS during their consultation proceedings, considering the UES, and will not be discussed further.

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 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, and that any exposure to ejecta would be in the form of relatively slow moving material sinking to the bottom near the animal. Empirical evidence from MMIII tests corroborates predictions of the propagation of shock waves approximately 37.5 m (123 ft) through the adjacent reef from the point of impact on the shoreline (USAFGSC and USASMDC/ARSTRAT 2015). 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, 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.

Corals, mollusks, and larval fish in the BOA
Corals and mollusks in a pelagic environment would be considered planula and would most likely die after approximately 80 days (depending on species) if settlement of the substratum were not to occur. Given the nature of the BOA, settlement would most likely occur on man-made material (i.e. trash), or other natural debris. Larval fish, while they do disperse, would not be expected to traverse such great distances or pass biogeographical barriers, or be present in such quantity or fine scale distribution to be affected by an impact of a missile component. Local dispersal nearshore could potentially occur and will be discussed later in Section 6. However, some individuals could potentially be affected in the BOA considering the exposure mechanism of missile components falling randomly into the ocean along the potentially unique flight paths. Larvae would be extremely small, widely distributed based on ocean conditions, are extremely poor swimmers, and most likely would not be present at the ocean surface where the greatest velocity of a falling object would occur. Furthermore, considering the size of the missile components, the size of ocean and environmental influences like currents, waves, swells, etc.; and the precision and accuracy required to hit an animal a fraction of a millimeter, is most likely unquantifiable and highly unlikely. NMFS therefore concludes that direct impacts from missile components in the BOA to larval stages of fish, corals, and mollusks is highly unlikely and therefore discountable.

Non-larval Fish, Corals, and Mollusks near Illeginni Islet
Non-larval forms of coral, mollusk, and fish species have the potential to occur on the reefs and waters in the vicinity of Illeginni Islet. These forms include the relevant coral and mollusk species and adults and juveniles of the relevant fish species under consideration. Although coral reefs are not planned or expected to be targeted, a land payload impact on the shoreline of Illeginni could result in ejecta/debris fall, shock waves, and post-test cleanup operations, which may affect and will likely adversely affect at least some of the consultation fish, coral and mollusk species on the adjacent reef. The analysis of these potential effects are analyzed below in section 6.

<u>c. Exposure to hazardous materials</u>:
For all of the species considered in this consultation, exposure to action-related hazardous materials is expected to have insignificant effects. During each over-ocean flight, any substances of which the launch vehicle is constructed or that are contained on the launch vehicle and are not consumed during flight or spent motor jettison will fall into the BOA when first-, second-, and third-stage launch vehicle motors and nose fairing are released. The launch vehicle includes rocket motors, solid rocket propellant, aluminized Hydroxyl Terminated Polybutadiene, battery electrolytes, radio frequency transmitters, and small electro-explosive devices. Though the batteries carried onboard the rocket motors would be discharged by the time they splash down in the ocean, they would still contain small quantities of electrolyte material. The amount of other toxic substances, such as battery acid, hydraulic fluids, explosive residues and heavy metals is relatively small. The affected areas would be very small locations within the drop zones, and the hazardous materials within the missile component debris would sink quickly to the seafloor; well

away from protected marine species. Materials leaked at the surface and in the water column as the debris sinks would be quickly diluted by the enormous relative volume of sea water, aided by the debris' movement through the water column and by ocean currents, thus never 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. On the seafloor, the materials would leak or dilute in water, be dissipated by ocean currents, or leach into bottom sediments. It is discountable that any of the consultation species would encounter the diluted materials near the seafloor, or in the bottom sediments.

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 quickly cleaned up. All waste materials would be transported to Kwajalein Islet for proper disposal in the US.

With the payload impact on Illeginni, debris including hazardous materials would fall on Illeginni and possibly into nearshore habitats. The payload structure itself contains heavy metals including aluminum, titanium, steel, magnesium, tungsten, and other alloys. The payload carries up to 175 pounds of tungsten alloy (i.e. metal) which will enter the terrestrial and possible marine environments upon impact per test flight. However, as this portion of the device is the payload, a dud possessing the largest portion of intact material, could be recovered and disposed of properly once located. Debris and ejecta from a land impact would be expected to fall within 91 m (300 ft) of the impact point. Post-flight cleanup of the impact area will include recovery/cleanup of all visible alloy debris including during crater backfill. Searches for debris would be attempted out to water depths of 55 m (180 ft) if debris enters the marine environment. Only trace amounts of hazardous chemicals are expected to remain in terrestrial areas and would be considered by the USFWS in their consultation proceedings. If any hazardous chemicals enter the marine environment, they are expected to dilute and disperse quickly by currents and wave action. Considering attempts to remove all visible alloy debris will occur, the quantities of potential hazardous materials, the planned land impact, expected blast radius, explosion mechanics, and the dilution and mixing capabilities of the ocean and lagoon waters, we believe that any effects from chemicals will be insignificant to protected species in the area.

<u>d. Disturbance from human activities and equipment operation</u>:
Many of the activities done to complete pre-flight preparations and post-flight restoration work at Kwajalein Atoll would take place in marine waters inhabited by protected marine species covered by this consultation. Elevated levels of human activity are expected for up to 10 weeks at Illeginni Islet. During this period, several vessel round-trips are likely. Helicopters will also be used to transport equipment and personnel to Illeginni Islet. The Action is expected to involve as many as 2 dozen personnel on Illeginni Islet during the 10-week period. Those activities may affect any of the species considered in this consultation should those species encounter or be directly impacted by ongoing activities. However, none of the planned activities would intentionally contact marine substrates or consultation species, except those activities taken to restore in-water areas that may be impacted by payload impacts at Illeginni Islet. Impact restoration actions that may be taken in marine waters around Illeginni Islet may adversely affect species identified in Table 1, but not any of the species identified in Table 2. The sessile species in Table 2 (16 corals and black-lip pearl oyster) are not likely to occur in the area where they

could be affected considering these species' range, distribution, and habitat preferences. These species do not occur in area where missile impacts or debris recovery actions are expected to occur and will not be affected by human disturbances from the proposed action. Similarly, the mobile species in Table 2, either do not occur in the area that may be impacted, or they are expected to temporarily leave the area with no measurable effect on their fitness. The potential effects of in-water restoration activities on the corals and top shell snails in Table 1 will be considered later in the *Effects of the Action Section*.

For all other operations (vessel movement, dive operations, deployment and recovery of the LIDSS rafts, etc.) the most likely reaction to exposure to the activities, would be a short-term avoidance behavior, where motile species such as marine mammals, sea turtles, and fish temporarily leave the immediate area with no measurable effect on their fitness, then return to normal behaviors within minutes of cessation of the activity. 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. Physical contact by personnel during the debris recovery portion of the operations with sessile species (see Table 1) could occur. However, all coral colonies expected to be affected by the proposed action are already accounted for in the *Effects of the Action* later in the document as this is the maximum number of colonies which may be present. Planned protective measures would reduce the potential for this interaction by watching for and avoiding protected species during the execution of pre-flight preparations and post-impact restoration work. Based on the best available information, project-related disturbance may infrequently cause an insignificant level of behavioral disturbance for the species identified in Table 2, but may adversely affect the species identified in Table 1.

<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, however it is discountable that any of the species considered in this consultation would experience a collision with a project-related vessel. As part of ARRW test monitoring and data collection, sea-based sensors will be deployed along the flight path on vessels in the BOA. The USAF with the support of USASMDC/ARSTRAT are proposing to use a Landing Craft Unit (LCU), MATSS, and M/V Worthy (224-foot long vessel), and may use various small vessels including an ROV if they need to retrieve debris in deep areas. These vessels travel from various U.S. locations or Kwajalein Atoll to locations along the flight path. Smaller vessels will launch from the larger vessels or a local ramp or pier. Pre-flight activities at or near USAKA will include vessel traffic to and from Illeginni Islet. Prior to launch, radars will be placed on Illeginni Islet and would be transported aboard ocean-going vessels. Sensor rafts will also be deployed near the impact site from a LCU vessel. Approximately eight to ten vessel round trips to Illeginni will be conducted for each of the test flights, for a total of up to 40 round trips over a two-year period.

Post-flight, payload debris recovery and clean-up will take place at Illeginni Islet. These post-test cleanup and recovery efforts will result in increased vessel traffic to and from Illeginni Islet. Vessels will be used to transport heavy equipment (such as backhoe or grader) and personnel for manual cleanup of debris, backfilling or any craters, and instrument recovery. Deployed sensor rafts will also be recovered by a LCU vessel. In the event of an unintended shallow water impact or debris entering the shallow water environments from a land impact near the shoreline, debris would be recovered. Smaller boats will transport divers, and ROVs if needed, to and from Illeginni to locate and recover this debris in waters up to approximately 30.5 m (100 ft) deep on the ocean side of Illeginni and within 152 to 305 m (500 to 1,000 ft) of the islet's shoreline on the lagoon side.

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, and humphead wrasse 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. 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.

There is no designated critical habitat within the RMI or BOA. Therefore, the proposed action may affect the designated critical habitat identified above, but would have no effect on critical habitat in the RMI or BOA.

Considering the information presented above, and in the best scientific information available about the biology and expected behaviors of the marine species considered in this consultation, we agree that exposure to the proposed action would have insignificant effects, or the likelihood of exposure would be discountable for the consultation species identified in Table 2.

Therefore, we concur with your determination that conducting the proposed ARRW flight test is NLAA the consultation species identified in Table 2. Those species and critical habitat will not be considered further in this consultation.

5 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, USASMDC/ARSTRAT determined that the proposed action was likely to adversely affect the 11 marine UES consultation species listed in Table 1.

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 4.18 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).

5.1 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.

5.1.1 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 (15 ft) 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 (Personal Communication Dr. Robert Schroeder, NMFS). Two neighboring seaward reef flat sites in 2008 were noted to have adult humphead wrasse present (USFWS 2011a); thus, a total of eight adult individuals might be exposed to potential MMIII impacts in this region. Absent a direct physical or sound related impact, the adults might be expected to show temporary curiosity, altered feeding patterns, and/or displacement.

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

5.1.2 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.

5.1.3 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.

5.1.4 Conservation of the Species

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

5.2 *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.

5.2.1 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).

5.2.2 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 16 to 66 ft (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).

5.2.3 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.

5.2.4 Conservation of the Species

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

5.3 *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.

5.3.1 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. ploystoma* is reported as uncommon to common (Veron 2014). Within the area potentially impacted at Illeginni, *A. ploystoma* 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).

5.3.2 Life History Characteristics Affecting Vulnerability to Proposed Action

A. polystoma is a stony coral. The soft tissue of stony corals harbor mutualistic intracellular symbiotic dinoflagellates called zooxanthellae, which are photosynthetic. The zooxanthellae allow scleractinian corals to gain most of their food through photosynthesis during the day, switching to more capture of microscopic prey with nematocysts on their tentacles at night. Corals also absorb significant amounts of microorganic compounds and free nutrients (Bythell, 1990; Grover et al. 2008). However, the dominant feeding mode varies among species and some species can shift among them as needed Grottoli et al. 2006).

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 33 ft (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).

5.3.3 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.

5.3.4 Conservation of the Species

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

5.4 *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.

5.4.1 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).

5.4.2 Life History Characteristics Affecting Vulnerability to Proposed Action

C. agassizi is a scleractinian coral. It 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 7 to 66 ft (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).

5.4.3 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 is lightly 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.

5.4.4 Conservation of the Species

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

5.5 *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.

5.5.1 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).

5.5.2 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 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 as 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 197 ft (60 m). It is most abundant from the shallow reef crest down to forereef slopes at 33 ft (10 m), but is still common down to 60 ft (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).

5.5.3 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.

5.5.4 Conservation of the Species

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

5.6 *Pavona venosa* (Coral)

P. venosa is a broadly distributed Indo-Pacific coral. 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.

5.6.1 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).

5.6.2 Life History Characteristics Affecting Vulnerability to Proposed Action

P. venosa is a 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 nematocysts that are used for prey capture and defense. Individual polyps secrete corallite over the skeletons of its predecessors, and each polyp is connected to adjacent polyps by a thin layer of interconnecting tissue. The soft tissue of stony corals harbor mutualistic intracellular symbiotic dinoflagellates called zooxanthellae, which are photosynthetic. The zooxanthellae allow scleractinian corals to gain most of their food through photosynthesis during the day, switching to more capture of microscopic prey with nematocysts on their tentacles at night. Corals also absorb significant amounts of microorganic compounds and free nutrients (Bythell, 1990; Grover et al. 2008). However, the dominant feeding mode varies among species and some species can shift among them as needed (Grottoli et al. 2006).

P. venosa typically forms massive to encrusting colonies attached to hard substrate. It occurs in shallow reef environments at depths of about 7 to 66 ft (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).

5.6.3 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.

5.6.4 Conservation of the Species

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

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

5.7.1 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 (3 to 89 ft; CBD 2018).

Pocillopora meandrina is considered a "competitive" species (Darling et al. 2012), which is typically efficient at using resources and can dominate communities in productive environments. *Pocillopora meandrina* is often observed abundant locally throughout its range. Although there is little species specific, range-wide data on *P. meandrina'*s abundance and population trends, there are some data available on the species' abundance and population trends in the main Hawaiian Islands portion of the Hawaiian archipelago, which indicate a significant decrease in coral cover over a recent 14-year period. It is likely that *P. meandrina* has declined in abundance across most, if not all, of its range, over the past 50 to 100 years, and that the decline has recently accelerated.

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.

5.7.2 Life History Characteristics Affecting Vulnerability to Proposed Action

Pocillopora meandrina has a branching colony morphology, is a broadcast spawner, and has rapid skeletal growth, allowing it to recruit quickly to available substrate and successfully compete for space (Darling *et al*, 2012). High recruitment rates, rapid skeletal growth, and successful competition are well documented for *P. meandrina* in Hawaii (*e.g.*, Jokiel and Brown, 2004; Grigg and Maragos, 1974) and the eastern Pacific (*e.g.*, Jiménez and Cortés, 2003).

While such competitive reef coral species typically dominate ideal environments, they also have higher susceptibility to threats such as elevated seawater temperatures than reef coral species with generalist, weedy, or stress tolerant life histories (Darling et al. 2012).

5.7.3 Threats to the Species

Major threats to *Pocillopora meandrina* include destruction and/or modification of habitat, harvest for the aquarium trade, disease, predation, and most importantly a 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). After the most recent coral resilience survey in 2018, the coral reef resilience survey team estimated that branching *Pocillopora* species (including *P. meandrina*) populations were reduced by 70% respectively by a mass bleaching events in consecutive years that killed most of the colonies (Doug Fenner, coral taxonomist and biologist, pers com May 2018, BECQ unpub. data, CREP unpub. data). That said, the life history characteristics of *P. meandrina* such as recruitment and settlement to a variety of substrates, and rapid growth provide some buffering against threats such as warming-induced bleaching and die-offs. For example, in 2016, *P. meandrina* populations in the main Hawaiian Islands were already showing signs of recovery from the 2014 and 2015 bleaching mortality (PIFSC, unpublished data).

5.7.4 Conservation to the Species

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

5.8 *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.

5.8.1 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).

5.8.2 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 130 ft (0 to 40 m), commonly on forereef slopes at 33 ft (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 spawner; releasing gametes of one sex or the other that become fertilized in the water (Brainard et al. 2011).

5.8.3 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.

5.8.4 Conservation of the Species

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

5.9 *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).

5.9.1 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).

5.9.2 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.

5.9.3 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.

5.9.4 Conservation of the Species

The top shell is afforded protection at USAKA as a consultation species under the UES (USAKA 2018).

5.10 *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).

5.10.1 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).

5.10.2 Life History Characteristics Affecting Vulnerability to Proposed Action

H. hippopus is a giant clam of the subfamily Tridacninae, 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, *Symbodinium*.

5.10.3 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. 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).

5.10.4 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.

5.11 *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).

5.11.1 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 2004a). 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).

5.11.2 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 2004a). Like other tridacnines, the lifespan of *T. squamosa* has not been determined; although it is estimated to vary widely between 8 to several hundred years (Soo and Todd 2014). See section 5.10.2 for more information on the life history characteristics of tridacnines.

5.11.3 Threats to the Species

Current threats include are similar to those of *H. hippopus*, and include: acidification, disease, pollution, exploitation, and thermal stress. 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).

5.11.4 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.

6 Environmental Baseline

The UES does not specifically describe the environmental baseline for a biological opinion. However, under the ESA, the environmental baseline includes: past and present impacts of all State, Federal, or private actions and activities in the action area; the anticipated impacts of all proposed Federal projects in the action area that have already undergone 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 within a biological opinion is to provide the context for the effects of the proposed action on the 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.

The Marshall Islands consist of 29 atolls and 5 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, and the total lagoon area is about 4,500 square miles. Kwajalein

Atoll is located near the center of the island group, about 8 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 (including Illeginni Islet) 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 the Marshallese live on. 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 in California, and other locations. Payload impacts from such tests have occurred and continue to occur on and in the vicinity of Illeginni Islet and in adjacent ocean waters.

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.

Minuteman III operations through the year 2030 was estimated to harm or kill up to 49,645 colonies of the 15 species of UES corals and 117 top shell snails (NMFS 2015). The USASMDC/ARSTRAT also estimated take of 9,929 colonies of 15 species of corals, 117 top shell snails, ten *Hippopus hippopus* giant clams, and two *Tridacna squamosa* giant clams by the U.S. Navy’s Flight Experiment-1 (FE-1) test.

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). The take estimated in the FE-1 tests accounted for accidental mishits in the shoreline. The FE-1 were completed in 2017 and mishits were not reported. Therefore the amount and level of take of FE-1 is likely to have been far fewer than estimated. Additional surveys could show that they are indeed in the area but not at higher levels than estimated.

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).

Changes in ocean temperature and chemistry, and rising sea level may be affecting the black-lip pearl oyster in the action area, but no specific information is currently available to assess the impacts. Because this species depends 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, with the exception of impacts related to zooxanthellae.

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).

7 Effects of the Action

In this section of a biological opinion, we assess the probable effects of the proposed action on UES-protected species. Effects of the Action refers to the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action that would be added to the environmental baseline. Direct effects are caused by exposure to the action related stressors that occur at the time of the action. Indirect effects are those that are caused by the proposed action and are later in time, but still are reasonably certain to occur (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. Since no critical habitat has been designated in the RMI, impacts on critical habitat are not considered in this Opinion.

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.

7.1 Stressors

As described above in Section 3, we believe that the proposed action would cause five stressors that may affect the consultation species considered in this consultation: exposure to elevated noise levels; impact by falling missile components; exposure to hazardous materials; disturbance from human activity and equipment operation; and collision with vessels. Of those stressors, impact by falling missile components, specifically for the payload that would target Illeginni Islet, is the only stressor that is likely to adversely affect consultation species. The remaining stressors are expected to have insignificant effects and/or exposure is discountable (extremely unlikely to occur), and those stressors are discussed above and no further in this Opinion.

Similarly, Section 3 described why all of the species identified in Table 2 are unlikely to be adversely affected, and therefore considered no further in this Opinion. In summary, the 7 coral species, top shell snail, and two giant clams identified in Table 1 may be hit by the falling payload or by ejecta, or be significantly affected by concussive forces during the four planned payloads targeting Illeginni Islet.

Note: Within the 7 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 7 corals 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.

7.1.1 Exposure to Impact by Falling Missile Components

This section analyzes the proposed action's potential for exposing UES-consultation corals, giant clams, top shell snails, and humphead wrasses to being hit by the ARRW test payload or ejecta thereof planned to strike on Illeginni Islet. Based on estimates of the ejecta field and cratering for MMIII RVs, ARRW is expected to produce an ejecta field from crater formation at impact that would cover a semicircular area (approximately 120º) extending no more than 91 m (300 ft) from the impact point. The density of ejecta is expected to decrease with distance from the point of impact (USAFGSC and USASMDC/ ARSTRAT 2015). Because the size of the payload and vehicles of the ARRW missile is smaller, we expect craters from ARRW payloads to be smaller than MMIII RV craters which have been documented to be 6 to 9 m (20 to 30 ft) in diameter and 2 to 3 m (7 to 10 ft) deep. We also 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), and a revised report based on a survey in Illeginni in 2017 (NMFS 2017a, 2017b). 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. As previously mentioned, one survey conducted in the impact area of MMIII found some of these corals to be there in lower densities than previously estimated or not in the area in the ground they covered (NMFS 2017a). The MMIII estimates are still the best estimates at this time because these corals could still be in the area and densities may change with additional surveys but they are not expected to be any higher than what was estimated for MMIII or FE-1 (S. Kolinski, NMFS-PIRO, Pers. Comm., 2017).

Therefore, the anticipated worst-case scenario of a payload land impact at Illeginni islet is considered to be a shoreline strike, which would result in debris fall and shock wave effects within an affected area that would extend outward from the point of strike. On both sides of Illeginni Islet, the area potentially affected by shock waves is encompassed within the area potentially affected by debris fall (Figure 3). Since these areas overlap and since harmed individuals should be counted only once in the effects of the Action, the affected habitat area with the largest estimated take should be selected as the worst-case scenario. The debris fall affect area is larger than the shock wave affect area; therefore, we calculated the effects of the Action based on the debris fall/ejecta area. Although the exact shape of the affect area is impossible to predetermine, the seaward portion of such an area is conceptually illustrated as a rough semi-circle on the lagoon and ocean sides of Illeginni Islet with a radius of 91 m (300 ft).

The aerial extent of potential debris fall effects on the lagoon and ocean sides of Illeginni were calculated to be ½ (πr^2) or 13,008 m^2 (15,557 yd^2). Each of these areas (Figure 3) would be subject to potential debris fall based on debris fall distance analyses for similar impacts of the MMIII RVs (USAFGSC and USASMDC/ARSTRAT 2015) and the FE-1 payload (US Navy 2017a). Based on the best professional judgment of NMFS survey divers, approximately 80% or 10,406 m^2 (12,445 yd^2) of the lagoon-side effect area (Figure 3) is considered potentially viable habitat for consultation fish, coral, and mollusks (NMFS-PIRO 2017c). Similarly, approximately 75% or 9,756 m^2 (11,668 yd^2) of the ocean-side effect area (Figure 3) is considered potentially viable habitat for consultation fish, coral, and mollusk species (NMFS 2017a).

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 by each of the four tests 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, we assume that the entire are will be affected and these analyses should be regarded as an overestimate and those of maximum effect.

Figure 3. Representative Maximum Direct Contact Affect Areas for a Shoreline Payload Impact at Illeginni Islet, Kwajalein Atoll.

To account for the unevenness of impact across the area, and to avoid double counting potential exposures, the USASMDC/ARSTRAT estimates that 50% of the 12,445 yd^2 (10,406 m^2) potentially affected suitable habitat would be affected by the combination of ejecta and/or shock waves would equal 6,223 yd^2 (5,203 m^2). The 99% upper confidence level of the bootstrap mean densities for the potentially affected consultation species in the area was multiplied by the areal extent of potentially affected suitable habitat to estimate the number of coral colonies and top shell snails that may be adversely affected by ejecta and/or shockwave effects by payloads landing Illeginni Islet (Table 77).

Table 7. Marine UES consultation species likely to be adversely affected by ejecta and/or shockwaves by payload shoreline strike.

Scientific Name	Species	Colonies or Individuals Affected
Corals		
Acropora microclados	No Common Name	17
A. polystoma	No Common Name	17
Cyphastrea agassizi	No Common Name	14
Heliopora coerulea	No Common Name	4,683
Pavona venosa	No Common Name	14
Pocillopora meandrina	Cauliflower coral	5,658
Turbinaria reniformis	No Common Name	14
Mollusks		
Tectus niloticus	Top Shell Snail	4
Hippopus hippopus	Giant clam	78
Tridacna squamosal	Giant clam	12
Fish		
Cheilinus undulates	Humphead wrasse	108

7.2 Response to Falling Missile Components

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

The ARRW payload 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 close to the impact area. Based on previous tests, the resulting crater is expected to be up to 30 ft (9 m) across and 10 ft (3 m) deep. As previously discussed, the payload fragments and ejecta are expected to occur within 91 m (300ft) of a payload’s impact point, correlating to an approximate ocean depth of less than 3 m (10 ft). 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. 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 123 ft 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 77, represent a conservative yet reasonable estimate of the corals that may be adversely affected by the proposed action considering all four projectiles over the two year period. 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 (123 ft). 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 acts 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 at 6.2, 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 3), 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 up to 4 top shell snails may be exposed to the combined effects of a payload land strike (Table 7, above), would be adversely affected by the exposure.

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 foraging 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 at 6.2, 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 (see Section 3), 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 fewer than 90 (78 *H. hippopus* and 12 *T. squamosa*) exposed to the combined effects of a payload land strike, would be adversely affected by the exposure.

In the case of the humphead wrasse, the USASMDC/ARSTRAT estimated that there will be up to 100 juvenile, and eight humphead wrasses will be in the area of impact pictured in Figure 3 over the course of the two-year period when all four tests will occur. 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 (300 feet 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) 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. Absent a major mishit that lands into the water in one large piece, it is unlikely that any humphead wrasse will be actually be contacted by ejecta.

7.3 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.

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

As described in the exposure analyses above, up to 10,417 colonies of 15 UES-consultation coral species (Table 77) could experience mortality from all payload strikes on Illeginni Islet. This would be due to the combined exposure to direct payload impact, ejecta, and ground-based shockwaves. Each payload intends to strike the exact same target location and this is the maximum number of coral colonies which are expected to be present within the impact zone over the proposed actions time frame (2 years).

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 at 6.2, 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 10,417 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 shockwaves 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.

7.3.2 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 four top shell snails could experience mortality as the result of direct payload impact from all four payload strikesejecta, and ground-based shockwaves over a two year period. 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 at 6.2, 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 four 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 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.

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

As described in the exposure and response analyses above, we expect up to 78 *H. hippopus* and 12 *T. squamosa* clams could experience mortality as the result of a single direct payload impact or cumulatively from all four payload strikes, ejecta, and ground-based shockwaves over a two year period. 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 at 6.2, 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 90 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 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.

7.3.4 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 108 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 at 6.2, 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 108 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.

8 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 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). Cumulative effects, as defined in the ESA, 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 (as described in the Environmental Baseline section) 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 as corals, marine mollusks, and reef fish.

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. 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 and unstudied, 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 top shell snails 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 this species because it depends 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, with the exception of impacts related to zooxanthellae.

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 and mollusk considered in this Opinion.

9 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 (USAKA 2018). "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 6 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 4.

9.1 Corals

As described in the Effects of the Action section, a total of up to 10,417 colonies of UES-consultation corals (7 species) could be injured or 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; *Pocillopora meandrina* and *Heliopora 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).

As discussed more fully in the Environmental Baseline and Cumulative Effects sections, the effects of fisheries interactions, direct take, and climate change are expected to continue and likely worsen in the future for these corals. However, the impact and time scale of these effects on the trajectory of the affected coral populations at USAKA, and across Oceania is currently uncertain, and those impacts are expected to occur on a time scale against which the impacts of the proposed action would be indistinguishable.

The proposed action is anticipated to result in the mortality of up to 10,417 coral colonies at Illeginni Islet. These coral colonies represent a small fraction of the total number of their species found at Illeginni, and even less around USAKA. 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 the 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.

9.2 Top Shell Snail

As described in the Effects of the Action section, a total of up to four 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 coastal development, direct take, and climate change are expected to continue and likely worsen in the future for this species. However, the impact and time scale of these effects on the trajectory of the affected top shell snail populations at USAKA is currently uncertain, and those impacts are expected to occur on a time scale, against which the impacts of the proposed action would be indistinguishable.

The proposed action is anticipated to result in death of up to four 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. The potential loss of four 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.

9.3 Giant Clams

As described in the Effects of the Action section, a total of up to 90 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, (9 for *H. hippopus* and 6 for *T. squamosa*) as well as at 9 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 coastal development, direct take, and climate change are expected to continue and likely worsen in the future for this species. However, the impact and time scale of these effects on the trajectory of the affected giant clam populations at USAKA is currently uncertain, and those impacts are expected to occur on a time scale, against which the impacts of the proposed action would be indistinguishable.

The proposed action is anticipated to result in death of up to 90 giant clams (78 *H. hippopus* and 12 *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. 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.

9.4 Humphead Wrasse

As described in the Effects of the Action section, a total of up to 108 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 coastal development, direct take, and climate change are expected to continue and for climate change in particular expect to worsen in the future. However, the impact and time scale of these effects on the trajectory of the humphead wrasse population at USAKA is currently uncertain, and those impacts are expected to occur on a time scale, against which the impacts of the proposed action would be indistinguishable.

The proposed action is anticipated to result in the injury or death of up to 108 humphead wrasse (100 juveniles and 8 adults) at Illeginni over the two year period when all four tests will occur. 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. 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 giant clams at Illeginni, or appreciably reduce the likelihood of their survival and recovery across USAKA including the MAC.

10 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 USASMDC/ARSTRAT's implementation of the ARRW flight tests at the Reagan Test Site, 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, or two species of giant clams, and humphead wrasse. As described above in Section 3, no critical habitat has been designated or proposed for designation for any UES-protected marine species in the action area or elsewhere in the RMI. Therefore, the proposed action would have no effect on designated or proposed critical habitat.

11 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 USAG-KA, 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.

11.1 Anticipated Amount or Extent of Incidental Take

Based on the analysis in the accompanying Opinion we conclude that the FE-1 flight test at the USAG-KA RTS, would result in the take of seven species of UES consultation corals, top shell snails, two clam species, and humphead wrasses. As described above in the exposure and response analyses, we expect that 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.

11.2 Effect or Impact of the Take

In the accompanying 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.

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

11.4 Terms and Conditions

The USASMDC/ARSTRAT 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 USASMDC/ARSTRAT shall ensure that their personnel comply fully with the best management practices and conservation measures identified in the BA and below.
    a. The USASMDC/ARSTRAT 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 USASMDC/ARSTRAT 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 USASMDC/ARSTRAT 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 USASMDC/ARSTRAT 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 USASMDC/ARSTRAT shall assign appropriately qualified personnel to record all suspected incidences of take of any UES-consultation species.
    b. The USASMDC/ARSTRAT 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 USASMDC/ARSTRAT shall require its personnel to survey the ejecta field for impacted corals, top shell snails, clams, and humphead wrasse. 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 USAG-KA environmental office. USASMDC/ARSTRAT, USAG-KA, 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, USAG-KA 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.

12 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 USASMDC/ARSTRAT 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 USASMDC/ARSTRAT continue to work with NMFS staff to conduct marine surveys at additional sites around all of the USAG-KA islets and in the

mid-atoll corridor to develop a more comprehensive understanding of the distribution and abundance of species and habitats at USAG-KA.

3. We recommend that the USAG-KA 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 USAG-KA.
    c. Develop mechanisms to collect and disseminate the information.

Reinitiation Notice

This concludes formal consultation on the implementation of the ARRW flight test program at the USAKA RTS, 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.

13 DATA QUALITY ACT DOCUMENTATION AND PRE-DISSEMINATION REVIEW

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.

13.1 Utility

Utility principally refers to ensuring that the information contained in this consultation is helpful, serviceable, and beneficial to the intended users. The intended users of this Opinion are the SSP, and USASMDC/ARSTRAT. Other interested users could include the citizens of RMI, USFWS, and NOAA. Individual copies of this Opinion were provided to the USASMDC/ARSTRAT and will be available through NMFS' Pacific Island Regional Office. The format and naming adheres to conventional standards for style.

13.2 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.

13.3 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 training in ESA and reviewed in accordance with Pacific Islands Region ESA quality control and assurance processes.

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