- FINAL -

Air-Launched Rapid Response Weapon (ARRW) Environmental Assessment / Overseas Environmental Assessment

United States Air Force

July

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14. ABSTRACT:
This EA/OEA provides analysis for test series 1 and test series 2 of the Air-launched Rapid Response Weapon (ARRW) within the boundaries of the Pacific Ocean. The candidate impact area included in this EA/OEA for test series 2 is Illeginni Islet, U.S. Army Garrison–Kwajalein Atoll.

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FINDING OF NO SIGNIFICANT IMPACT

AIR-LAUNCHED RAPID RESPONSE WEAPON (ARRW)

ENVIRONMENTAL ASSESSMENT / OVERSEAS ENVIRONMENTAL ASSESSMENT

AGENCY: United States Air Force Life Cycle Management Agency

ACTION: Finding of No Significant Impact

BACKGROUND: The Proposed Air-launched Rapid Response Weapon (ARRW) system test is sponsored by the Office of the Under Secretary of Defense for Research and Engineering [USD (R&E)], which has designated the United States Air Force (USAF) Life Cycle Management Center (LCMC) as the lead agency and action proponent for the Proposed Action. The Proposed Action entails test series 1 and test series 2 of the ARRW. ARRW test series 1 and test series 2 are expected to be completed within a reasonable time from the completion of this Environmental Assessment (EA)/Overseas Environmental Assessment (OEA) and signing of the Finding of No Significant Impact (FONSI). The USAF, along with the U.S. Army Space and Missile Defense Command (USASMDC) as a participating agency, has prepared this EA/OEA in accordance with the National Environmental Policy Act (NEPA) (42 United States Code [USC] § 4321, as amended), the Council on Environmental Quality (CEQ) Regulations for Implementing the Procedural Provisions of NEPA (Title 40 Code of Federal Regulations [CFR] Parts 1500–1508, July 1, 1986), the Department of the Army Procedures for Implementing NEPA (32 CFR Part 651), and USAF Environmental Impact Analysis Process (EIAP), 32 CFR Part 989 and Environmental Impacts: Policies and Procedures; and Executive Order 12114 – Environmental Effects Abroad of Major Federal Actions.

DESCRIPTION OF PROPOSED ACTION AND ALTERNATIVES: The Preferred Alternative (Alternative 1) consists of ARRW test series 1 and test series 2; designed to prove various aspects of the system's capabilities. ARRW test series 1 and 2 components would be carried externally on B-52 aircraft and released in-flight. Aerial-drop and flight is anticipated to occur at 12.2 kilometers (km; 40,000 feet [ft]) or greater.

Point Mugu Sea Range (PMSR), part of the Naval Air Warfare Center Weapons Division (NAWCWD) Point Mugu, is located off the Pacific Coast of Southern California and supports test and evaluation of sea, land, and air weapons systems. PMSR provides a safe volume of air and sea space in which to conduct controlled tests. PMSR comprises 93,200 square kilometers (km^2; 36,000 square miles [mi^2]) of ocean area. PMSR extends from less than 5.6 km (3 nautical miles [nm]) to more than 370 km (200 nm) off the California coastline. The splashdown area for the ARRW test series 1 is the broad ocean area (BOA) of the Pacific Ocean and includes waters outside of exclusive economic zones (EEZs). The EEZs extend 370 km (200 nm) seaward from identified territorial sea baselines. For the purposes of the ARRW test series 1, the boundaries of the BOA are defined as beginning at the point of aerial drop and initial solid rocket motor ignition, terminating within the BOA. Additionally, for the purposes of the ARRW test series 2, the boundaries of the BOA are defined as beginning at the point of aerial drop and initial solid rocket motor ignition, terminating with impact at Illeginni Islet. Aerial drop and vehicle ignition could occur within the boundaries of PMSR or the BOA. After air-drop of the ARRW test series 1 vehicle over PMSR, the vehicle's solid rocket motor would ignite and the vehicle would travel westward. Once the motor is spent, the vehicle components, shroud and inert payload would splash down in the broad ocean area (BOA) of the Pacific.

After air-drop of the ARRW test series 2 vehicle over the BOA, the vehicle's solid rocket motor would ignite and the ARRW, with attached payload, would travel over the BOA towards the Reagan Test Site (RTS) at United States Army Garrison–Kwajalein Atoll (USAG-KA) in the Republic of the Marshall Islands (RMI). Once the motor is spent, the payload would separate, the vehicle components would fall into the BOA, and the payload would continue flight towards USAG-KA where it would impact at Illeginni Islet in Kwajalein Atoll. The ARRW test series 2 vehicle would incur a land impact at USAG-KA (Illeginni Islet) within an impact zone 290 meters (m) by 137 m (950 ft by 450 ft)) on the northwestern end of the islet. The mission planning process will aid in avoidance, to the maximum extent possible, of all potential risks to environmentally significant areas. The actual impact zone size and location (asphalt pad, field, etc.) on Illeginni Islet will be based on range safety requirements and chosen as part of the mission analysis process. The targeted area is selected to minimize impacts to identified wildlife habitats and reefs or shallow water.

This test is designed to collect data to provide a basis for ground testing, modeling, and simulation of payload performance. The Proposed Action entails pre-test preparation, aerial drop and ignition, flight tests, impact of the payload, and post-test activities coordinated with USAF, PMSR, USAG-KA and designated range safety authorities. The No Action Alternative was also evaluated. All alternatives are described below.

All test activities and flight paths have been developed in compliance with Range Commanders Council (RCC) – 321 range safety guidelines. If the ARRW 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.

ENVIRONMENTAL EFFECTS: In assessing environmental impacts of the Proposed Action, USAF LCMC identified potential effects to the following resource areas, which are analyzed in the attached EA/OEA: water resources, geological resources, cultural resources, land use, airspace, noise, transportation and infrastructure, public health and safety, hazardous materials and wastes, socioeconomics, environmental justice, visual resources, air quality, greenhouse gases, climate change, and biological resources. A review of the analysis for the Proposed Action (Alternative 1) is provided below.

Preferred Action (Alternative 1) PMSR:

- **Water Resources** – There are no groundwater or surface water resources within PMSR that would be affected by the ARRW test.

- **Geological Resources** – Due to the nature of the aerial drop of the ARRW components from a high altitude in PMSR's airspace, no impacts to geological resources or marine sediments from the ARRW flight tests are expected.

- **Cultural Resources** – Although there are known cultural resources within PMSR, no impacts to cultural resources from the ARRW test are expected to occur.

- **Land Use** – No changes to land use would occur from the ARRW test. The ARRW flight path would avoid populated land masses. There would be no impacts from the ARRW test to land use within PMSR.

- **Airspace** – No new special use airspace would be required, expanded, or altered for the ARRW tests. Local airport operations would not be affected. Commercial and private aircraft would be notified through Federal Aviation Administration (FAA) Notice to Airmen (NOTAMs) in advance of the test flight as part of their routine operations. Flight operations would be conducted in accordance with Western Range procedures. There would be no impacts to airspace from the ARRW tests in PMSR.

- **Noise** – The ARRW tests will occur offshore within PMSR. A sonic boom would occur in PMSR when the ARRW test series 1 vehicles reach the speed of sound. No impacts would occur from noise as a result of the ARRW test.

- **Transportation and Infrastructure** – Transportation services and infrastructure would be unaffected by the ARRW test. The ARRW test would occur at high altitude where it would be generally undetected by vessels or aircraft. Public NOTAMs and Notices to Mariners (NTM) would be issued along the flight path, to protect the safety of aircraft and vessels.

- **Public Health and Safety** – The ARRW flight would occur at high altitudes where it would be generally undetected by vessels or aircraft. NOTAMs and NTMs would be issued along the flight path to ensure the safety of personnel on aircraft and vessels. If the ARRW were to deviate from its course or should other problems occur during aerial drop and ignition that might jeopardize public safety, the onboard FTS would be activated. This action would initiate a destruct charge causing the ARRW to terminate flight and fall into PMSR. The FTS would be designed to prevent debris from falling into any protected area. No inhabited land areas would be subject to unacceptable risks of falling debris. The probability of impacts to public health and safety would be extremely low.

- **Hazardous Materials and Waste** – The solid rocket motor would ignite and the ARRW vehicle would fly out of PMSR in a westward trajectory. Because the Proposed Activity is for ARRW test series 1 to launch within PMSR within a reasonable timeframe following signature of the FONSI, the amount of emissions is considered negligible. If the ARRW test series 1 onboard FTS is activated within PMSR, it is possible for debris to fall towards the ocean within PMSR. *De minimis* residual quantities of materials may remain on the vehicle and would be carried to the ocean floor by the sinking components. The relatively small quantities of hazardous waste and dilution from ocean water indicate that there would be no impacts of hazardous materials and wastes from the ARRW test.

- **Socioeconomics** – There is no resident population at PMSR. Therefore, there would be no impacts to socioeconomics from the ARRW test.

- **Environmental Justice** – PMSR does not include any population centers; there is no resident population located at PMSR. Therefore, there would be no disproportionate impacts from the ARRW tests to minority populations and low-income populations as defined under Executive Order (EO) 12898.

- **Visual Resources** – There would be no changes to and, therefore, no impacts to the visual aesthetics at PMSR from the ARRW tests series 1.

- **Air Quality, Greenhouse Gases, and Climate Change** – The aerial drop of the ARRW test series 1 over PMSR is expected to take place at an altitude of 12.2 km (40,000 ft). The action would introduce atomic chlorine, aluminum oxide particles, and nitrogen oxides produced from emissions of hydrogen chloride during high-temperature afterburning reactions in the exhaust plume of the solid rocket motor propellent. The Proposed Action is for ARRW test series 1 (within PMSR) to be conducted within a reasonable time after completion of this EA/OEA and signed FONSI. The effect of the ARRW tests on local PMSR air quality would be negligible because the aerial drop would take place over 914 m (3,000 ft) and therefore above the atmospheric inversion layer. The short duration of the flight tests, the length of time between the flight tests, the low emissions of the rocket exhaust, and the ignition location offshore in PMSR collectively indicate that the Proposed Action would not cause any lasting effects to PMSR air quality.

- **Biological Resources** – The following stressors have the potential to impact biological resources at PMSR: exposure to elevated sound pressure levels, direct contact from falling components, and exposure to hazardous chemicals. Overall, biological resources are not expected to be impacted by any ARRW test stressors at PMSR. Any realized elevated noise level effects would be limited to short-term startle reactions, and animals would be expected to return to normal behaviors within minutes. Under normal ARRW operations, biological resources are not expected to be subject to direct contact or exposure to hazardous chemicals.

Preferred Action (Alternative 1) BOA:

- **Water Resources** – There are no groundwater or surface water resources within the BOA that would be affected by the ARRW test series 1 or ARRW test series 2. There would be no disturbance to ocean waters beyond the spent motor and shroud splashing into the ocean along the flight path, sinking thousands of meters (feet). There is a low probability that the spent motor could float on the ocean surface post-splashdown. Buoyancy analysis shows that if there is no case breach during splashdown, then the spent motor (during the ARRW test series 2) can float. Floating debris is considered unlikely; however, there is a low probability that the spent motor could float on the ocean surface post-splashdown. No impacts to water resources are anticipated within the over-ocean flight corridor (BOA) from the ARRW test series 1 or 2.

- **Geological Resources** – There would be no drilling, mining, or construction in the open ocean associated with the ARRW test series 1 or 2. No marine sediment disturbance beyond the settling of the spent motor, inert payload, and shroud as they come to rest on the sea floor would occur. No impacts to geological resources or marine sediments from the ARRW test series 1 or 2 are expected.

- **Cultural Resources** – There are no identified cultural resources within the BOA; therefore, there would be no impacts to cultural resources from the ARRW test series 1 or 2.

- **Land Use** – The ARRW test series 1 or 2 flight paths would avoid populated land masses. There would be no changes to land use. No impacts to land use are expected within the BOA.

- **Airspace** – The ARRW flight corridor is located over international airspace within the BOA and, therefore, has no formal airspace restrictions governing it. Over-ocean flight tests must comply with Department of Defense (DOD) Instruction 4540.01, Use of International Airspace by U.S. Military Aircraft and for Missile/Projectile Firings. Commercial and private aircraft would be notified through NOTAMs issued through the FAA in advance of the ARRW test series 1 and 2 tests at the request of RTS as part of their routine operations. ARRW test operations would be conducted in accordance with Western Range procedures and would not expand or alter currently controlled airspace. Therefore, there would be no impacts to airspace within the BOA from the ARRW test series 1 or 2.

- **Noise** – The ARRW test series 1 and 2 would occur at an altitude where it would be generally undetected by vessels or aircraft at the ocean's surface. Only the sonic boom created by the solid rocket motor ignition of the ARRW test series 2 would occur over the BOA. Therefore, there would be no impacts from noise within the BOA.

- **Transportation and Infrastructure** – Transportation services and infrastructure, as applicable, would be unaffected by the ARRW test. The ARRW test would occur at high altitude where it would be generally undetected by vessels or aircraft. Public NOTAMs and NTMs would be issued along the flight path, to protect the safety of aircraft and vessels. The inert payload of the ARRW vehicle, and components of the ARRW test series 2 vehicles would drop to the ocean surface within the predetermined BOA to ensure, along with the public notices, that there would be no vessels or aircraft in the vicinity. There would be no impacts from the ARRW test series 1 or 2 to transportation or infrastructure along the flight path over the open ocean.

- **Public Health and Safety** – The ARRW test series 1 and 2 tests would occur at high altitudes where they would be generally undetected by vessels or aircraft. NOTAMs and

NTMs would be issued along the flight path to ensure the safety of personnel on aircraft and vessels. Components would drop over predetermined open ocean areas to ensure, along with the public notices, that there would be no vessels or aircraft in the vicinities. If the ARRW test series 1 or 2 were to deviate from course or should other problems occur during flight that might jeopardize public safety, the onboard FTS would be activated. No inhabited land areas would be subject to unacceptable risks of falling debris. There would be no anticipated impacts to public health and safety associated with the ARRW test series 1 or 2, and flight trajectory over the BOA.

- **Hazardous Materials and Waste** – During ARRW test series 2 tests, the ARRW system would be aerially dropped within the BOA, and the vehicle would fly over the BOA in a westward trajectory towards Illeginni Islet. During ARRW test series 1 and 2, the solid rocket motor would exhaust on-board propellant prior to separation and before the spent stage drops into the ocean. *De minimus* residual quantities of materials may remain on the spent stage and shroud and would be carried to the ocean floor by the sinking components. There are no anticipated impacts from hazardous materials and wastes to the over-ocean flight corridor (BOA) from the ARRW test series 1 or 2 tests.

- **Environmental Justice** – Range safety regulations and procedures protective of health and safety would be applied during flight test operations. There would be no disproportionate impacts within the BOA to minority populations or low-income populations under EO 12898. There are no anticipated impacts to environmental justice from the ARRW test series 1 or 2.

- **Visual Resources** – The ARRW test series 1 and 2 would occur at high altitude where it would be generally undetected by vessels or aircraft. There would be no changes to and, therefore, no impacts to the visual aesthetics within the BOA from the ARRW flight tests.

- **Air Quality, Greenhouse Gases, and Climate Change** – Vehicle emissions, from the ARRW test series 1 and 2, would occur as propellant is burned from point of vehicle ignition, within the BOA to splashdown within the BOA (ARRW test series 1) or impact at Illeginni Islet (ARRW test series 2). Approximately 1,633 kilograms (kg) (3,600 pounds [lb]) of Hydroxyl Terminated Polybutadiene (HTPB) are released over a period of minutes, for the ARRW test series 1 and 2. At temperatures below 770 Kelvin (K), the main gaseous product of HTPB is butadiene, whereas the range of products arises as the temperature increases. At 1,170 K, butadiene accounts for only 1–2 percent (%) of the products, and the primary product is ethylene, with light hydrocarbons.

  On a global scale, the quantity of ethylene and light hydrocarbon emissions from a single ARRW test series 1 or 2 would represent a very small fraction of ethylene and hydrocarbons generated. Diffusion of the gases in the atmosphere and winds would disperse the ethylene and hydrocarbons. No significant effect on ozone levels from ethylene and hydrocarbons is expected. Therefore, impacts from a single ARRW test series 1 or 2 would not be expected to have a significant impact on the upper atmosphere. Rocket motor emissions from the ARRW test series 1 and 2 would not have a significant impact on stratospheric ozone depletion. Ozone-depleting gas emissions from the single flight test would represent such a minute increase that any incremental effects on the global atmosphere would be discountable and insignificant.

- **Biological Resources** – The following stressors have the potential to impact biological resources in the BOA: exposure to elevated sound pressure levels, direct contact from ARRW component splashdown, exposure to hazardous chemicals, and exposure to increased vessel traffic. Any realized elevated sound pressure effects would likely be limited to short-term startle reactions, and animals would be expected to return to normal behaviors within minutes. Due to the low density and patchy distribution of important or sensitive biological resources in the BOA, the chances of an ARRW component directly contacting an animal are extremely low. Given that the density of sensitive biological resources in this area is low and seasonal, the likelihood of an important or sensitive biological resource being impacted by human disturbance, encountering hazardous materials, or being struck by a vessel is also likely very low and no effects are expected. Overall, the Proposed Action would have no significant impacts on biological resources in the BOA.

Preferred Action (Alternative 1) Illeginni Islet:

- **Water Resources** – Subsequent to impact, fresh water would be used to minimize fugitive dust; waters would not be allowed to flow to the lagoon or ocean and would evaporate in place. In the unlikely event of an accidental release of a hazardous material or petroleum product at the impact site (associated with vehicles used during cleanup and site restoration), emergency response personnel would comply with the United States Army Kwajalein Atoll Environmental Standards, Kwajalein Environmental Emergency Plan (UES KEEP). Due to the presence of no surface waters bodies or fresh groundwater, no impacts to water resources would be expected from ARRW test series 2 activities.

- **Geological Resources** – There would be slight, if any, surface disturbance during the placement of equipment prior to the flight tests. While a temporary crater would be created at impact on Illeginni Islet, the crater would be refilled with ejecta and clean fill materials (from either off island or on island quarry), and the site topography restored. For a deep-water impact, there would be no marine sediment disturbance beyond the settling of the spent stage and shroud as they come to rest on the sea floor. No impacts to geological resources or marine sediments from the ARRW test series 2 are expected.

- **Cultural Resources** – The ARRW test series 2 impacts are proposed to occur on the west end of Illeginni Islet. Archaeological surveys have not found indigenous cultural materials or evidence of subsurface deposits on the islet. The Cold War-era properties potentially eligible for listing on the RMI National Register of Historic Places (NRHP) are located in the central and eastern portions of the islet. Because a land impact would not occur in proximity to known or potential cultural resources on Illeginni Islet, implementation of the Proposed Action is not anticipated to result in impacts to cultural resources.

- **Land Use** – No changes to land use at Illeginni Islet would occur from the ARRW test series 2. The ARRW test series 2 activities are consistent with the RTS mission and are well within the limits of current operations of RTS and United States Army Garrison Kwajalein Atoll (USAG-KA). No impacts to land use from the ARRW test series 2 are anticipated.

- **Airspace** – Illeginni Islet is located under international airspace and, therefore, has no formal airspace restrictions. No new special use airspace would be required, expanded, or altered for the ARRW test series 2. Commercial and private aircraft would be notified through FAA NOTAMs in advance of the test flight at the request of RTS as part of their routine operations. Flight operations would be conducted in accordance with Western Range and RTS procedures. There would be no impacts to airspace from the ARRW test series 2.

- **Noise** – Terminal flight of the ARRW test series 2 over the RMI would create a sonic boom carpet along its flight path. Because of the vehicle's high-altitude during flight, maximum elevated SPLs from sonic booms beneath the flight path would be 145 decibels (dB) until descent. During vehicle descent, a focused boom would occur over the intended site and the nearby areas of the Atoll. At the terminal end of the flight path, the sonic boom generated by the approaching ARRW is estimated to peak at less than 180 dB. At the point of impact, the sonic boom footprint would narrow. For payload impact at Illeginni Islet, elevated sound pressure levels (SPLs) due to the sonic boom would be present in the air over land and would also be present in the surrounding waters. The duration for sonic boom overpressures produced by the payload are expected to average 75 milliseconds (ms) where SPLs are greater than 140 dB and 270 ms where SPLs are less than 140 dB. Approximately 1 km^2 (0.4 mi^2) would be exposed to SPLs up to 170 dB. Because the sonic boom footprints at impact normally do not overlap any RMI communities, there are no residents within 29 km (18 miles [mi]) of Illeginni Islet, the sonic boom would be audible only once at any nearby locations and last no more than a fraction of a second. Noise levels during pre-test and post-flight activities at the predetermined target site would occur in an unpopulated area without resident receptors. Range evacuation procedures are implemented during all flight tests, and no residents or personnel are expected to be subjected to significant noise-related impacts. Therefore, no short-term, or long-term, impacts would occur from noise as a result of the ARRW test series 2.

- **Transportation and Infrastructure** – There would be no changes to infrastructure at Illeginni Islet. The Proposed Action represents activities that are consistent with the mission and well within the limits of current operations of RTS and USAG-KA. Transportation services would be unaffected by the ARRW test series 2. Public NOTAMs and NTMs would be issued along the flight path, to include Kwajalein Atoll, to protect the safety of aircraft and vessels. Transport of ARRW test series 2 materials, equipment, and personnel to and from USAG-KA and the impact site would occur using existing transportation methods. ARRW test series 2 activities are consistent with the mission and well within the limits of current operations of RTS and USAG-KA. Therefore, there would be no impacts to transportation within RMI, at Kwajalein Atoll or Illeginni Islet.

- **Public Health and Safety** – There are no resident populations at or in proximity to Illeginni Islet. A NOTAM and an NTM are transmitted to appropriate authorities to clear commercial, private, and non-mission military vessel and aircraft traffic from caution areas and to inform the public of impending missions. Radar and visual sweeps of hazard areas would be regularly scheduled and conducted prior to launch to clear any non-mission ships and aircraft. No impacts to public health and safety are anticipated with the ARRW test series 2.

- **Hazardous Materials and Waste** – The ARRW would descend onto Illeginni Islet and break up on impact. Hazardous materials in the payload would be limited to batteries, small electro-explosive devices, and a tungsten alloy. No solid or liquid propellants would be carried on the payload. Considering the quantities of hazardous materials contained in the batteries and land impact, the battery materials released during payload impact should be of little consequence. All explosive devices would be handled in accordance with DOD 6055.09-STD. Sampling and analyses of soils and groundwater are planned to be conducted after each ARRW flight test. If analyses of ARRW post-flight test soil samples indicated tungsten levels above Residential levels, remedial techniques would be considered and suggested for consideration to the United States Environmental Protection Agency (USEPA). In the event of an accidental discharge (fuels, oils, etc.) during test flight operations or post-test cleanup activities, ground personnel would comply with the UES KEEP controlling the spill site and cleanup. No short-term or long-term impacts from materials associated with either the ARRW flight tests or accidental spills are anticipated.

- **Socioeconomics** – Personnel conducting the ARRW flight tests (series 2) would reside only temporarily at USAG-KA, and the ARRW flight tests would not employ any Marshallese citizens or contribute to the local Marshallese economy. There is no resident population at Illeginni Islet. Therefore, there would be no impacts to socioeconomics from the ARRW flight tests.

- **Environmental Justice** – There is no resident population located at Illeginni Islet. Therefore, there would be no disproportionate impacts from the ARRW test series 2 to minority populations and low-income populations as defined under EO 12898. No impacts to Environmental Justice are anticipated.

- **Visual Resources** – There would be no changes to and, therefore, no impacts to the visual aesthetics at USAG-KA Illeginni Islet from the ARRW test series 2.

- **Air Quality, Greenhouse Gases, and Climate Change** – The ARRW test series 2 would not emit hazardous air pollutants during impact at Illeginni Islet and no major stationary emission sources would be used during the ARRW test series 2. Fugitive dust from a land impact would be temporary and quickly dispersed by trade winds. Prior to debris recovery at Illeginni Islet, the area would be wetted with freshwater to minimize fugitive dust. The

ARRW test series 2 would not affect climate change. No impacts to air quality or greenhouse gases (GHGs) would be expected from the ARRW test series 2.

- **Biological Resources** – The following stressors have the potential to impact biological resources at Illeginni Islet: exposure to elevated sound pressure levels, direct contact from ARRW test series 2 terminal impact, exposure to hazardous chemicals, and exposure to increased human activity and equipment operation. The payload impact zone at Illeginni Islet is previously disturbed habitat and covered predominantly in impervious surface or managed vegetation. Therefore, no adverse impacts to vegetation are expected. Birds would be exposed to SPLs high enough to cause behavioral disturbance; however, any behavioral or physiological response is likely to be very brief and no adverse impacts to birds on or near Illeginni Islet are expected. Any effects of elevated noise levels on marine wildlife would likely be limited to brief startle responses and behaviors would quickly return to normal. Therefore, no adverse impacts are expected from elevated SPLs. Direct contact from payload debris and ejecta is not likely to affect birds or sea turtles in terrestrial habitats. Very few birds are expected to be within this area and no sea turtle nesting activity has been reported on Illeginni Islet in over 20 years. Direct contact from payload impact is not expected to adversely affect cetaceans or sea turtles in the water. Cetaceans, sea turtles in the water, and most fish are unlikely to be adversely impacted by increased human activity or equipment operation or hazardous chemical at Illeginni Islet. Based on evaluation of a worst-case scenario of a shoreline impact, direct contact from payload debris or human activity and equipment operation may affect several UES-protected coral colonies, individual mollusks, and humphead wrasses. Due to the potential for the Proposed Action to adversely affect these species, the USAF consulted with the National Marine Fisheries Service (NMFS). The NMFS found that up to 10,417 UES consultation coral colonies, four top shell snails, 90 clams, and 108 humphead wrasses might be injured or killed by the Proposed Action. The NMFS also concluded that the potential loss of these individual fish, snails, and clams, and coral colonies would not be likely to jeopardize the continued existence of any of these UES consultation species at USAG-KA.

No Action Alternative: Under the No Action Alternative, the Proposed Action would not occur, and the USAF would not pursue the ARRW program flight tests.

CONCLUSION: The environmental analysis in this EA/OEA for the ARRW test series 1 and 2 determined that implementation of the Proposed Alternative, or the No Action Alternative, would not have a significant environmental impact on the human and natural environment, either by itself or cumulatively with other actions. After thoroughly considering the facts herein, the undersigned finds that implementation of the Proposed Action is consistent with existing environmental policies and objectives set forth in NEPA and its implementing regulations. Preparation of an Environmental Impact Statement, therefore, is not required.

PUBLIC REVIEW AND COMMENT: In the Republic of the Marshall Islands the USASMDC published an availability notice in local newspapers from 6 to 7 June 2020 announcing a 30-day public review and comment period for the June 2020 version of the Final ARRW EA/OEA and Draft FONSI.

During the 30-day review period that ended on 7 July 2020, the U.S. Army Space and Missile Defense Command had received no comments from the general public.

POINT OF CONTACT: The EA addressing this action may be obtained from: U.S. Army Space and Missile Defense Command, Post Office Box 1500, Huntsville, AL 35807-3801, Attn: David Fuller, (256) 955-5585.

APPROVED:

Signature: BARD.MARYA.M.1103349644 Digitally signed by BARD.MARYA.M.1103349644 Date: 2020.08.10 10:35:09 -05'00' Date: 10 Aug 2020

Ms. Marya Bard

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Appendices

Figures

Tables

Acronyms and Abbreviations

%	Percent
°C	Degree(s) Celsius
°F	Degree(s) Fahrenheit
µPa	Micropascal(s)
ACHP	Advisory Council on Historic Preservation
AFB	Air Force Base
AFFTC	Air Force Flight Test Center
AICUZ	Air Installations Compatible Use Zones
AR	Army Regulation
ARRW	Air-launched Rapid Response Weapon
ARSTRAT	Army Forces Strategic Command
BA	Biological Assessment
BCC	Birds of Conservation Concern
$BKNO_3$	Boron Potassium Nitrate
BMP	Best Management Practice
BO	Biological Opinion
BOA	Broad Ocean Area
C_2H_4	Ethylene
CAA	Clean Air Act
CAAQS	California Ambient Air Quality Standards
CARB	California Air Resources Board
CATEX	Categorical Exclusion
CCA	Coast Conservation Act of 1988
CDFW	California Department of Fish and Wildlife
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFC	Chlorofluorocarbons
CFR	Code of Federal Regulations
CINMS	Channel Islands National Marine Sanctuary
CINP	Channel Islands National Park
CITES	Convention on International Trade in Endangered Species
cm	Centimeter(s)

CO	Carbon Monoxide
CWA	Clean Water Act
CZMA	Coastal Zone Management Act
dB	Decibel(s)
dBA	A-weighted decibels
dBpeak	Peak Decibel(s)
DEP	Document of Environmental Protection
DOD	Department of Defense
DODD	Department of Defense Directive
DPS	Distinct Population Segment
E	East
EA	Environmental Assessment
EEZ	Exclusive Economic Zone
EFH	Essential Fish Habitat
EIAP	Environmental Impact Analysis Process
EIS	Environmental Impact Statement
EO	Executive Order
ESA	Endangered Species Act
ESU	Evolutionarily Significant Unit
FAA	Federal Aviation Administration
FE-1	Flight Experiment 1
FE-2	Flight Experiment 2
FE-3	Flight Experiment 3
FONSI	Finding of No Significant Impact
FR	Federal Register
ft	Foot/Feet
ft^2	Square Foot/Feet
FTS	Flight Termination System
GHG	Greenhouse Gas
GRMI	Government of the Republic of the Marshall Islands
HAP	Hazardous Air Pollutant
HAPC	Habitat Area of Particular Concern
HPP	Historic Preservation Plan
HRC	Hawaii Range Complex

HSTT	Hawaii-Southern California Training and Testing
HTPB	Hydroxyl Terminated Polybutadiene
Hz	Hertz
ICBM	Intercontinental Ballistic Missile
in	Inch(es)
K	Kelvin
KEEP	Kwajalein Environmental Emergency Plan
kg	Kilogram(s)
km	Kilometer(s)
km^2	Square Kilometers
KMISS	Kwajalein Missile Impact Scoring System
KMRSS	Kwajalein Mobile Range Safety System
lb	Pound(s)
LCMC	Life Cycle Management Center
LCU	Landing Craft, Utility
LLNL	Lawrence Livermore National Laboratory
m	Meter(s)
m^2	Square Meter(s)
MATSS	Mobile At-Sea System
MBTA	Migratory Bird Treaty Act
mg/kg	Milligrams per Kilogram
mg/L	Milligrams per Liter
$mg/m^2/hr$	Milligrams per Square Meter per Hour
mi	Miles(s)
mi^2	Square Mile(s)
MITT	Mariana Islands Training and Testing
mm	Millimeter
MMIII	Minuteman III
MMPA	Marine Mammal Protection Act
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
ms	Millisecond(s)
MSA	Magnuson-Stevens Fishery Conservation and Management Act
MUORA	Military Use and Operating Rights Agreement

N	North
NAAQS	National Ambient Air Quality Standards
NASA	National Aeronautics and Space Administration
NAVFAC	Naval Facilities Engineering Command
NAWCWD	Naval Air Warfare Center Weapons Division
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
nm	Nautical Mile(s)
nm^2	Square Nautical Mile(s)
NMFS	National Marine Fisheries Service
NMSDD	Navy Marine Species Density Database
NO_2	Nitrogen Dioxide
NOA	Notice of Availability
NOAA	National Oceanic and Atmospheric Administration
NOTAM	Notice to Airmen
NPA	Notice of Proposed Activity
NRC	National Research Council
NRHP	National Register of Historic Places
NTM	Notice to Mariners
O_3	Ozone
OEA	Overseas Environmental Assessment
OEIS	Overseas Environmental Impact Statement
PAA	Payload Adapter Assembly
Pb	Lead
PCB	Polychlorinated Biphenyl
PFMC	Pacific Fisheries Management Council
PIRO	Pacific Islands Regional Office
PM_{10}	Suspended Particulate Matter
PMRF	Pacific Missile Range Facility
PMSR	Point Mugu Sea Range
ppm	Parts Per Million
ppt	Parts Per Trillion
PTS	Permanent Threshold Shift
RCC	Range Control Council

RCRA	Resource Conservation and Recovery Act
RDT&E	Research, Development, Test and Evaluation
re	Referenced To
RMI	Republic of the Marshall Islands
RMIEPA	Republic of the Marshall Islands Environmental Protection Authority
RMIHPO	Republic of the Marshall Islands Historic Preservation Office
RMS	Root Mean Square
ROD	Record of Decision
ROI	Region of Influence
ROV	Remotely Operated Vehicle
RSL	Regional Screening Levels
RTS	Ronald Reagan Ballistic Missile Defense Test Site (Reagan Test Site)
RV	Reentry Vehicle
S	South
SEL	Sound Exposure Level
SNI	San Nicolas Island
SO_2	Sulfur Dioxide
SOCAL	Southern California
SPCC	Spill Prevention, Control, and Countermeasures
SPL	Sound Pressure Levels
SRM	Solid Rocket Motor
STARS	Strategic Target System
TBD	To Be Determined
TDS	Total Dissolved Solids
TTS	Temporary Threshold Shift
U.S.	United States
UCL	Upper Confidence Limit
UES	United States Army Kwajalein Atoll Environmental Standards
UNEP	United Nations Environment Programme
USACE	United States Army Corps of Engineers
USAF	United States Air Force
USAFGSC	United States Air Force Global Strike Command
USAG-KA	United States Army Garrison Kwajalein Atoll
USAKA	United States Army Kwajalein Atoll

USAPHC	United States Army Public Health Command
USASMDC	United States Army Space and Missile Defense Command
USC	United States Code
USD (R&E)	Office of the Under Secretary of Defense for Research and Engineering
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
UXO	Unexploded Ordnance
W	West
yd^2	Square Yard(s)

Executive Summary

Introduction

The Proposed Air-launched Rapid Response Weapon (ARRW) system test is sponsored by the Office of the Under Secretary of Defense for Research and Engineering [USD (R&E)], which has designated the United States Air Force (USAF) Life Cycle Management Center (LCMC) as the lead agency and action proponent for the Proposed Action. The Proposed Action entails ARRW test series 1 and test series 2. ARRW test series 1 and 2 are expected to take place within a reasonable period after the completion of this Environmental Assessment (EA)/Overseas Environmental Assessment (OEA) and signing of the Finding of No Significant Impact (FONSI).

The environmental resource areas analyzed in this EA/OEA include air quality, water resources, geological resources, cultural resources, land use, airspace, noise, infrastructure, transportation, public health and safety, hazardous materials and wastes, socioeconomics, environmental justice, visual resources and biological resources.

Purpose and Need

The purpose of the Proposed Action, ARRW test series 1 and 2, is to demonstrate and collect data on key technologies, such as thermal control, precision navigation, guidance, control, and enabling capabilities of the ARRW vehicle and developmental payload during hypersonic flight. To meet these objectives, the ARRW test series 1 and 2 must satisfy certain physical and technical constraints. It is essential that the ARRW test series 2 configuration is capable of executing the planned flight profile within acceptable tolerances. The ARRW system must use observational instrumentation with sufficient fidelity to characterize and evaluate system performance.

Proposed Action and Alternatives Considered

Proposed Action

The Proposed Action evaluated in this EA/OEA is ARRW test series 1 and 2 flights, designed to prove various aspects of the ARRW system capabilities. The Proposed Action entails pre-test preparation, aerial drop and ignition, over-ocean flight, vehicle component splashdown, and impact of the payload.

Alternative 1

The ARRW, test series 1 and 2, would be carried externally on B-52 aircraft and released in-flight. Aerial-drop and flight is anticipated to occur at 12.2 kilometers (km; 40,000 feet [ft]) or greater. After air-drop of the ARRW test series 1 over Point Mugu Sea Range (PMSR), the vehicle's solid rocket motor will ignite and the vehicle (with an inert payload) will travel westward. Once the motor is spent, the spent motor, shroud, and inert payload will splash down in the broad ocean area (BOA) of the Pacific Ocean.

After air-drop of the ARRW test series 2 within the BOA, the vehicle's solid rocket motor will ignite and the ARRW test series 2 with attached payload will travel over the BOA towards the Reagan Test Site (RTS) at United States Army Garrison–Kwajalein Atoll (USAG–KA) in the Republic of the Marshall Islands (RMI). Once the motor is spent, the payload will separate, the spent motor and shroud will fall into the BOA, and the payload will continue flight towards USAG-KA where it will impact at Illeginni Islet in Kwajalein Atoll.

No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur, and USAF LCMC would not pursue the ARRW tests. If the ARRW tests do not occur, high-speed propulsion would not be validated and would not be put into use by the Department of Defense. The ARRW test is the next step in the development of key United States technologies for rapid response high-speed weapons systems. Failure to perform the ARRW tests would stall or halt the maturation of high-speed technologies necessary for the defense of the United States. The No Action Alternative would not meet the purpose and need for the Proposed Action.

Summary of Findings

The potential direct and indirect environmental impacts that might result from implementation of the Proposed Action and the No Action Alternative are summarized in **Table ES-1** for each of the resource topics analyzed in the EA/OEA.

Based on the assessment of other past, present, and reasonably foreseeable future actions in the vicinity of PMSR, the Proposed Action and No Action Alternative also could result in potential cumulative impacts on airspace management when combined with other actions. De minimis cumulative impacts are anticipated for all other resources.

Table ES-1. Potential Direct and Indirect Environmental Impacts from Implementation of the Proposed Action and the No Action Alternative

Location	Resource Area	No Action Alternative	Air-Launched Rapid Response Weapon (ARRW) Alternative 1
Point Mugu Sea Range (PMSR)	Noise	There would be no change to noise levels in the Regions of Influence (ROIs). Therefore, no significant impacts would occur from noise with implementation of the No Action Alternative.	The Proposed Action states that the ARRW series 1 flight tests would occur offshore within PMSR. A sonic boom would occur in PMSR as a result of the Proposed Action, particularly when the ARRW reaches high speeds. No short-term, or long-term, significant impacts would occur from noise as a result of the ARRW series 1 flight tests.
	Air Quality	Under the No Action Alternative, the flight tests would not occur and there would be no change to baseline air quality. No significant impacts to air quality or air resources would occur with implementation of the No Action Alternative.	The aerial drop by USAF aircraft of the ARRW over PMSR is expected to take place at an altitude of 12.2 kilometers (km; 40,000 feet [ft]) and over the ocean, away from the coast. The effect of the Proposed Action on local PMSR air quality would be negated because the ARRW aerial drop would take place over 914 meters (m; 3,000 ft), above the atmospheric inversion layer (U.S. Navy 2002). The Proposed Action would introduce atomic chlorine, aluminum oxide particles, and nitrogen oxides produced from emissions of hydrogen chloride during high-temperature afterburning reactions in the exhaust plume of the solid rocket motor propellent. This can contribute to long-term ozone depletion. The Proposed Action is for multiple series 1 flight tests over a reasonable period of time after the Final EA/OEA and FONSI is signed. The short duration of the flight test, the length of time between the flight tests, the low emissions of the rocket exhaust, and the ignition location offshore in PMSR collectively indicate that the Proposed Action would not cause any lasting effects to PMSR air quality.
	Biological	There would be no change to biological resources, and therefore, no significant impacts to biological resources from implementation of the No Action Alternative.	The proposed ARRW series 1 flight tests would not significantly impact marine vegetation at PMSR, and no special status vegetation species occur at PMSR. During normal operation, there would be no impacts to marine vegetation. Overall, marine wildlife is not expected to be impacted by any ARRW system stressors at PMSR. Though unlikely, any realized effects to marine mammals, sea turtles, fish, or invertebrates would be limited to short-term startle reactions, and animals would be expected to return to normal behaviors within minutes. It is not likely that any designated critical habitat, protected area, or essential fish habitat would be impacted by the ARRW series 1 flight tests. The ARRW air-drop would take place at least 93 km (50 nautical miles [nm]) from land and would not impact any protected habitats.

Location	Resource Area	No Action Alternative	Air-Launched Rapid Response Weapon (ARRW) Alternative 1
Broad Ocean Area (BOA)	Air Quality	Under the No Action Alternative, the ARRW flight test would not occur and there would be no change to baseline air quality. No significant impacts to air quality or air resources would occur with implementation of the No Action Alternative.	Thermal decomposition of Hydroxyl Terminated Polybutadiene (HTPB) in a rocket-motor environment is assumed to undergo the following pathway: HTPB⟶(ethylene ($C2H4$) and light hydrocarbon species On a global scale, the quantity of ethylene and light hydrocarbon emissions from a single ARRW test series 1 or 2 flight would represent a very small fraction of ethylene and hydrocarbons generated. Ethylene does not present a health hazard to humans or animals, as it is a naturally produced gas. Additionally, diffusion and winds would disperse the ethylene and hydrocarbons. No significant effect on ozone levels from ethylene and hydrocarbons is expected. Impacts from a single ARRW test series 1 or 2 flight would not be expected to have a significant impact on the upper atmosphere.
	Biological Resources	There would be no change to biological resources, and therefore, no significant impacts to biological resources from implementation of the No Action Alternative.	*Marine Wildlife*: Noise: Sonic booms overpressures would not exceed the physical injury thresholds for organisms in the BOA. There is a potential for behavioral disruption in fish and birds but only up to 2.2 m and 79 m (7.2 ft and 259 ft) respectively from the point/path of maximum sonic boom overpressures. Any realized effects would likely be limited to short-term startle reactions and fish and birds would be expected to return to normal behaviors within minutes. Therefore, no adverse impacts from sonic booms are expected. Splashdown pressures would not exceed the injury thresholds for mid- or low frequency cetaceans, pinnipeds, or sea turtles for any portion of the BOA. For high-frequency cetaceans, elevated sound levels from component splashdown exceed the Temporary Threshold Shift (TTS) threshold in the BOA; however, the risk of a cetacean in the high-frequency hearing group being exposed to Sound Pressure Level (SPL) high enough to cause TTS is extremely low. Marine wildlife may also be exposed to SPLs high enough to cause behavioral disturbance. While effects of elevated SPLs are possible, based on species abundance and distribution in the BOA, the chances of this occurring are likely very low. Any realized effects of elevated SPLs are likely to be temporary, behavioral modifications with no lasting effects. Therefore, no significant impacts from elevated SPLs are expected. Direct Contact: The chances of an ARRW component directly contacting a marine mammal are very low. The chances of direct contact with a sea turtle are also extremely low. Direct contact would not be expected to adversely impact marine mammals, sea turtles, birds, or fish in the BOA. Hazardous Chemicals: The release of hazardous materials carried onboard a launch vehicle would not significantly impact marine life. Hazardous materials would be rapidly diluted in the seawater, and larger and heavier vehicle components would sink fairly quickly to the ocean floor to depths where consultation organisms would likely not be in contact with these materials. Increased Human and Vessel Activity: Vessel traffic is common in this area, and the increase in human activity and vessel traffic in the BOA would be expected to be minimal; these activities would not be expected to adversely impact marine resources including threatened and endangered species.

Location	Resource Area	No Action Alternative	Air-Launched Rapid Response Weapon (ARRW) Alternative 1
United States Army Garrison–Kwajalein Atoll (USAG-KA), Republic of the Marshall Islands (RMI), Illeginni Islet	Cultural Resources	There would be no change to cultural resources under the No Action Alternative. Therefore, no impacts would occur to cultural resources with implementation of the No Action Alternative.	Archaeological surveys have not found indigenous cultural materials or evidence of subsurface deposits on Illeginni Islet. The Cold War-era properties potentially eligible for listing on the RMI National Register of Historic Places (NRHP) are in the central and eastern portions of Illeginni Islet. Because a land impact would not occur in proximity to known or potential cultural resources on Illeginni Islet, implementation of the Proposed Action would not result in significant impacts to cultural resources.
	Noise	There would be no change to noise levels in the ROI. Therefore, no significant impacts would occur from noise with implementation of the No Action Alternative.	While meteorological conditions can influence peak SPLs, the sonic boom generated by the approaching payload is estimated to peak at less than 180 decibels (dB). At the point of impact, the sonic boom footprint would narrow and duration for sonic boom overpressures are expected to average 75 to 270 milliseconds (ms). Approximately 1 square kilometer (km^2; 0.4 square mile [mi^2]) would be exposed to SPLs up to 170 dB. Noise model assumptions for estimating sonic boom overpressures likely lead to conservatively high estimates of sonic boom pressures and, therefore, conservative estimates of affected area. Mission vessel personnel may be required to use hearing protection. Noise levels during pre-test and post-flight activities at the pre-determined target site would occur in an unpopulated area without resident receptors. Therefore, no significant impacts would occur from noise with implementation of the No Action Alternative.
	Public Health and Safety	There would be no change to public health and safety under the No Action Alternative.	For impact, there are no resident populations in proximity to Illeginni Islet. Notices to Airmen (NOTAMs) and Notices to Mariners (NTMs) would be issued to clear traffic from caution areas prior to the test. There would be no significant impacts to public health and safety from the Proposed Action.
	Hazardous Materials and Wastes	Under the No Action Alternative, there would be no change to hazardous materials and waste at Illeginni Islet.	Hazardous materials used in the payload would be limited to batteries, small electro-explosive devices, and a tungsten alloy. No solid or liquid propellants, depleted uranium, beryllium, or radioactive materials would be carried on the payload. Flight test personnel would remediate the impact site, all visible debris would be removed, and all equipment and materials would be recovered from Illeginni Islet. Any hazardous waste resulting from ARRW test series 2 activities on Illeginni Islet would be disposed of in accordance with the USAG-KA Environmental Standards (UES). No significant impacts would occur from the Proposed Action.
	Biological Resources	There would be no change to biological resources under the No Action Alternative. Therefore, no impacts would occur to biological resources with implementation of the No Action Alternative.	*Terrestrial Veget*ation: The payload impact zone at Illeginni is previously disturbed habitat and is covered predominantly in impervious surface or managed vegetation. Therefore, no adverse impacts to terrestrial vegetation are expected. *Terrestrial Wildlife*: Noise: It is likely that birds would be exposed to SPLs high enough to cause behavioral disturbance. Any behavioral or physiological response is likely to be very brief and no adverse impacts to birds on or near Illeginni Islet are expected due to elevated SPLs.

FINAL

DISTRIBUTION A: Approved for Public Release, Distribution Unlimited.

Location	Resource Area	No Action Alternative	Air-Launched Rapid Response Weapon (ARRW) Alternative 1
			Direct Contact: While direct contact from payload debris may impact any birds in the impact zone, very few birds are expected to be within this area and the chances of direct contact are low. The United States Air Force (USAF) and the United States Army Space and Missile Defense Command (USASMDC) have concluded that since no sea turtle nesting activity has been reported on Illeginni Islet in over 20 years, the probability of sea turtle nesting in the area is so low as to be discountable and that ARRW test series 2 activities may but are not likely to adversely affect nesting sea turtles (USAF and USASMDC 2019). The United States Fish and Wildlife Service (USFWS) has concurred with this determination (Appendix A). Vessel Strike: No adverse impacts to birds are expected from vessels transiting to and from Illeginni Islet. Exposure to Hazardous Chemicals: Hazardous chemicals are not expected to impact birds at Illeginni Islet. While hazardous chemicals have the potential to impact nesting sea turtles, no sea turtle nesting activity has been recorded on Illeginni Islet in over 20 years; therefore, sea turtles are not expected to be adversely impacted. Human Disturbance: Disturbance from human activities and equipment operation has the potential to impact birds, especially nesting seabirds on Illeginni Islet; however, any disturbance is not expected to have a significant, long-term impact. Disturbance from human activities and equipment operation may but is not likely to adversely impact nesting sea turtles, sea turtle nests, and/or sea turtle nesting habitat. *Marine Wildlife*: Noise: The maximum SPLs for sonic booms and payload impact at the terminal end of payload flight do not exceed the physical injury thresholds for marine wildlife at USAG-KA. There is a potential for behavioral disruption near the payload impact point but only within 22 m (72 ft) of maximum sonic boom overpressures for cetaceans and sea turtles and 100 m (328 ft) for fish. Any realized effects would likely be limited to short-term startle reactions and marine wildlife would be expected to return to normal behaviors within minutes. Payload impact SPLs would result in SPLs above the injury threshold for fish but only out to 2.2 m (7.2 ft) from impact; since a land impact is planned, no fish would be physically injured by elevated sound pressures. There is a potential for behavioral disruption in sea turtles and fish near the payload impact point. While there is a chance that up to 20 green sea turtles and 7 hawksbill turtles may be exposed to SPLs high enough to elicit behavioral response, any response is expected to be temporary and turtles would be expected to return to normal behavior within minutes. Any behavioral disturbance in fish would likely be limited to a brief startle response and behaviors would quickly return to normal. Therefore, no adverse impacts are expected from elevated SPLs.

Location	Resource Area	No Action Alternative	Air-Launched Rapid Response Weapon (ARRW) Alternative 1
			Direct Contact: Payload impact is not expected to adversely affect cetaceans or sea turtles in the water through direct contact. Payload impact may adversely impact a very small, but indeterminable, number of larval fish, coral, or mollusks. The number of larvae potentially affected is likely to be trivially small relative to their population sizes and the effects are considered discountable. Based on analyses of a worst-case scenario of a shoreline impact, direct contact from payload debris may also affect up to 4,725 coral colonies, 79 individual mollusks, and 100 juvenile or 8 adult humphead wrasses. The National Marine Fisheries Service (NMFS) has been provided these analyses in a biological assessment, and they found that up to 10,417 UES consultation coral colonies, four top shell snails, 90 clams, and 108 humphead wrasses might be injured or killed by the Proposed Action. The NMFS also concluded that the potential loss of these individual fish, snails, and clams, and coral colonies would not likely jeopardize the continued existence of any of these UES consultation species at USAG-KA (NMFS 2019; Appendix C). Vessel Strike: Marine wildlife has the potential to be impacted by vessel strike primarily by being at the surface when a vessel travels through an area. Due to species characteristics, abundance, and distribution, and mitigation measures, no adverse impacts due to vessel strike are expected. Hazardous Chemicals: Post-flight cleanup of the impact area would include recovery/cleanup of all visible floating debris. Considering the small quantities of hazardous materials contained in the batteries, the planned land impact, and the dilution and mixing capabilities of the ocean and lagoon waters, the battery materials released during payload impact should be of little consequence to any cetaceans, fish, or sea turtles in the area. Human Disturbance: Cetaceans, sea turtles in the water, and most fish are unlikely to be adversely impacted by increased human activity or equipment operation at Illeginni Islet. In shallow waters near Illeginni, corals, mollusks, and reef-associated fish have the potential to be disturbed by shallow water debris recovery and/or backfill operations. NMFS has been provided a biological assessment, and the findings of their Final Biological Opinion are included in Appendix C.

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1.0 Purpose of and Need for the Proposed Action

1.1 Introduction

The Proposed Air-launched Rapid Response Weapon (ARRW) system test is sponsored by the Office of the Under Secretary of Defense for Research and Engineering [USD (R&E)], which has designated the United States Air Force (USAF) Life Cycle Management Center (LCMC) as the lead agency and action proponent for the Proposed Action. The Proposed Action entails ARRW flight test series 1 and test series 2. ARRW flight tests are expected to take place within a reasonable period of the completion of this Environmental Assessment (EA)/Overseas Environmental Assessment (OEA) and signing of the Finding of No Significant Impact (FONSI). The USAF, along with the U.S. Army Space and Missile Defense Command (USASMDC) as a participating agency, has prepared this EA/OEA in accordance with the National Environmental Policy Act (NEPA) (42 United States Code [USC] § 4321, as amended), the Council on Environmental Quality (CEQ) Regulations for Implementing the Procedural Provisions of NEPA (Title 40 Code of Federal Regulations [CFR] Parts 1500–1508, July 1, 1986), the Department of the Army Procedures for Implementing NEPA (32 CFR Part 651), and USAF Environmental Impact Analysis Process (EIAP), 32 CFR Part 989.

1.2 Locations

The locations analyzed in this EA/OEA are Point Mugu Sea Range (PMSR; **Figure 1-1**), the Broad Ocean Area (BOA) in the Pacific (**Figure 1-2**), and the U.S. Army Garrison–Kwajalein Atoll (USAG-KA) Illeginni Islet (northwest end; **Figure 1-3**).

PMSR, part of the Naval Air Warfare Center Weapons Division (NAWCWD) Point Mugu, is located off the Pacific Coast of Southern California and supports test and evaluation of sea, land, and air weapons systems. PMSR provides a safe volume of air and sea space in which to conduct controlled tests (U.S. Navy 2002). PMSR comprises 93,680 square kilometers (km^2; 36,000 square miles [mi^2]) of ocean area. PMSR extends from less than 5.6 kilometers (km; 3 nautical miles [nm]) to more than 370 km (200 nm) off the California coastline.

For the purposes of this document, the BOA is defined as an expanse of open ocean area of the Pacific encompassed by the extent shown in **Figure 1-2**. The BOA includes only waters outside of the Exclusive Economic Zones (EEZs) of the United States and other countries with territory in the central Pacific. An EEZ is defined as an area no more than 370 km (200 nm) from the territorial sea baseline (usually the mean low-water line) of these countries. Aerial drop and vehicle ignition could occur within the boundaries of PMSR or the BOA, with the flight azimuth heading in a westerly direction, away from land, with payload impacting at Illeginni Islet (**Figure 1-3**).

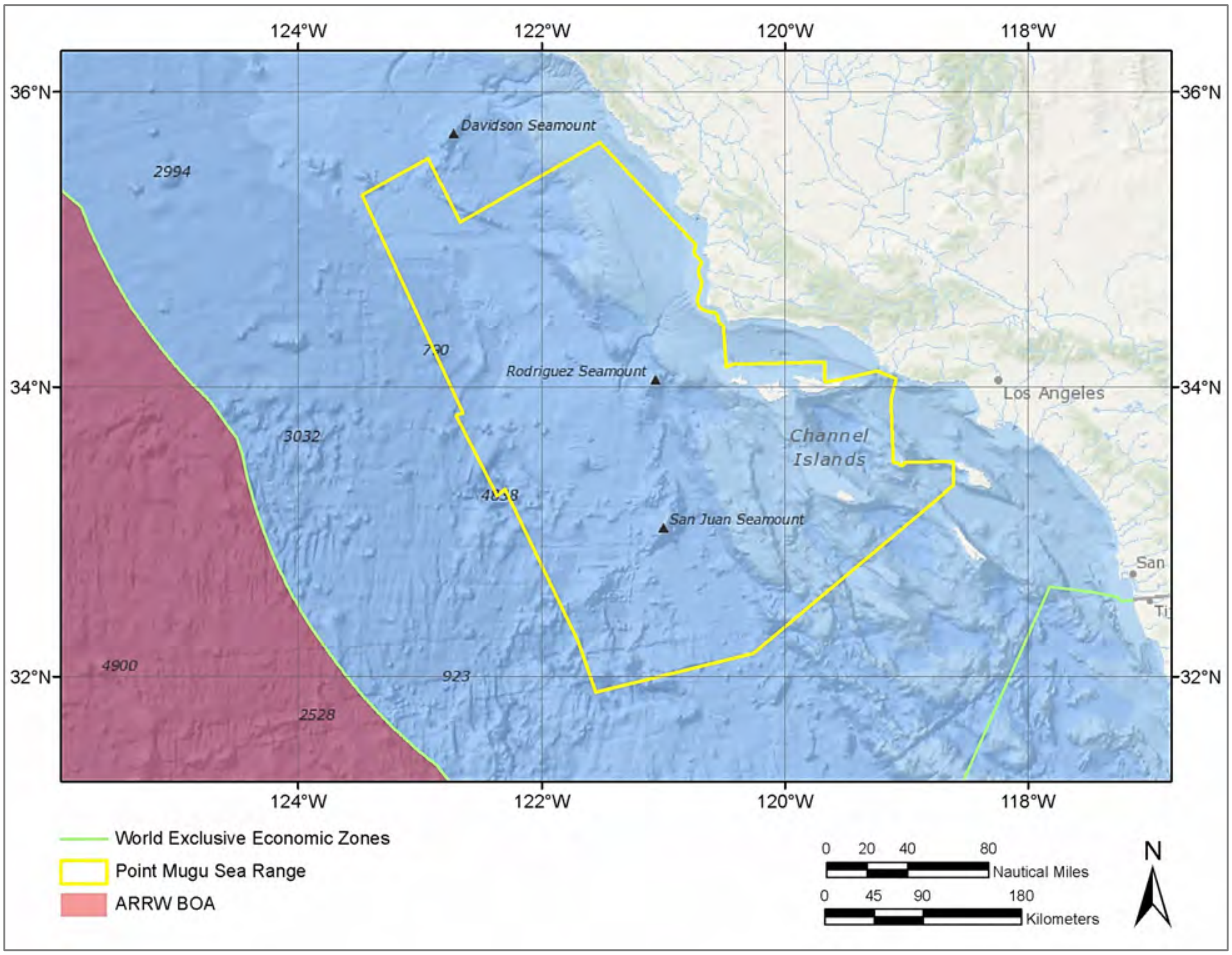

Figure 1-1. ARRW Activity Location Map – Point Mugu Sea Range

The ARRW flight tests would only include the essential components required to conduct a proper test, based on Test Series 1 and Test Series 2 flights (see **Section 2.1**). The ARRW test series 1 flight path would originate at aerial release from the B-52 somewhere over PMSR and extend from the air-drop location into the BOA. Once the motor is spent, the motor, shroud, and inert payload would splash down in the BOA of the Pacific. It is unknown at this time where in the BOA the spent components will splash down. Floating debris is considered unlikely; however, there is a low probability that the spent motor could float on the ocean surface post-splashdown.

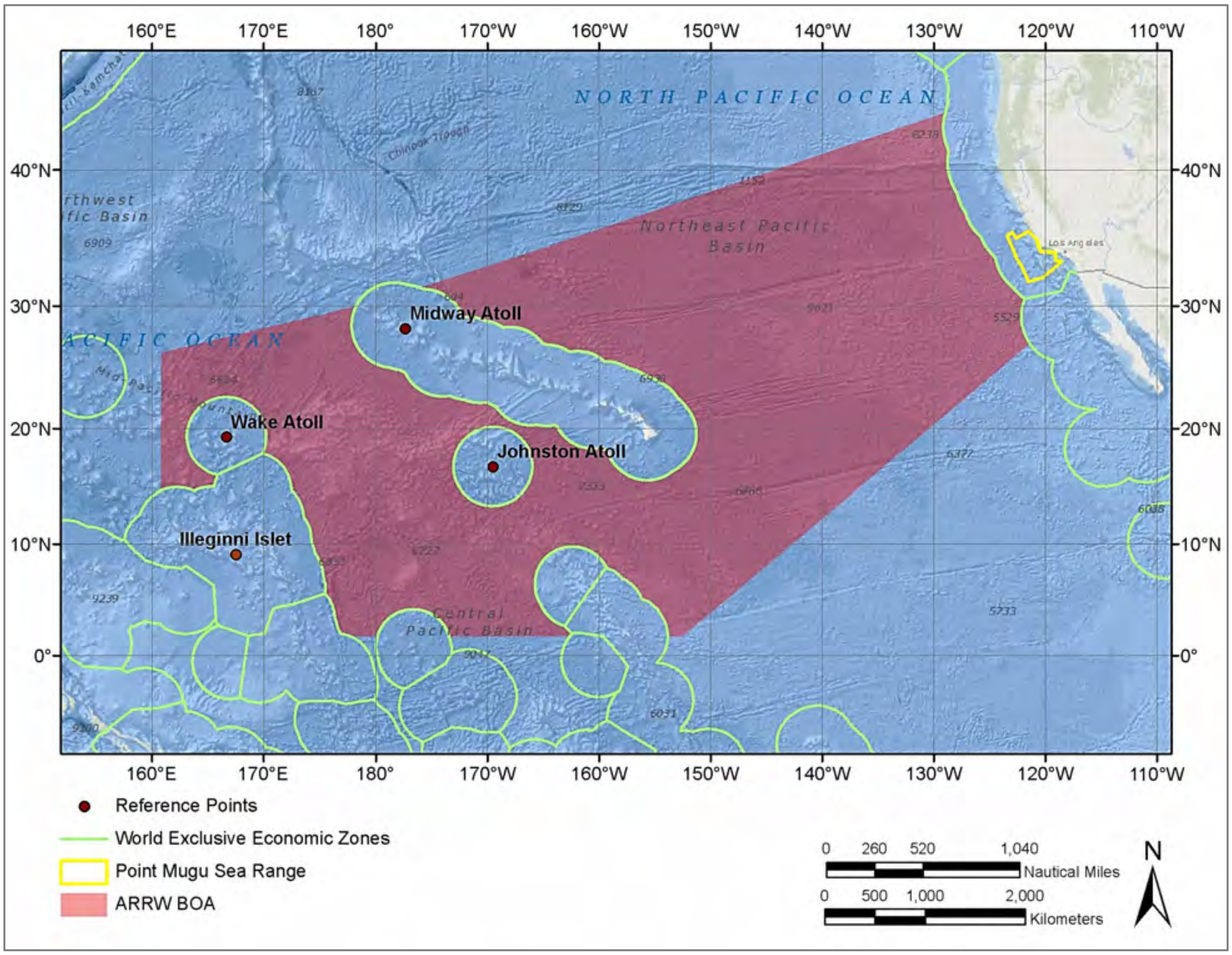

Figure 1-2. ARRW Activity Location Map Pacific – Broad Ocean Area

The ARRW test series 2 would consist of all components necessary to conduct a proper test (see Section 2.1). The ARRW components would splash down in the BOA of the Pacific Ocean following burnout and separation from the payload; and the payload would continue flight to the proposed impact location, Illeginni Islet (**Figure 1-3**). It is unknown at this time where in the BOA the spent motor and shroud would splash down; therefore, the entire BOA delimited in **Figure 1-2** is considered part of the Action Area. Floating debris would be considered unlikely; however, there is a low probability that the spent motor could float on the ocean surface post-splashdown. The ARRW test series 2 flight path would originate at aerial release (over the BOA) from the B-52 and extend from the air-drop location through the BOA to Kwajalein Atoll in the Republic of the Marshall Islands (RMI).

Figure 1-3. ARRW Activity Location Map – Illeginni Islet

1.3 Purpose of and Need for the Proposed Action

The Proposed Action, ARRW test series 1 and 2 flights are needed to demonstrate and collect data on key technologies. Flight tests will also aid in the maturation of the technologies necessary for the expansion of precision strike weapon system capabilities. Data collected will be utilized to test and mature models that predict the performance of the payload system. The Proposed Action would provide an opportunity to observe the ARRW from air-drop to impact and record all data along the flight path.

To meet the objectives described above, the ARRW test series 1 and 2 flights must satisfy certain physical and technical constraints. It is essential that the ARRW system is capable of executing the planned flight profile within acceptable tolerances. The ARRW system must characterize and evaluate system performance.

1.4 Scope of Environmental Analysis

This EA/OEA analyzes potential environmental impacts associated with the Proposed Action and the No Action Alternative. The USAF has considered alternate launch and impact locations. The USAF has proposed payload departure, in an underwing configuration, on a B-52 from either Edwards Air Force Base (AFB), California or Barksdale AFB, Louisiana, with aerial launch over PMSR and splash down in the BOA for the ARRW test series 1, and aerial launch within the BOA, transit through the BOA in the Pacific, and impact at Illeginni Islet for the ARRW test series 2 flight tests. This EA/OEA analyzes potential environmental impacts in PMSR (subsequent to aerial drop and motor ignition), the spent motor and shroud splashdown zones in the BOA, and at Illeginni Islet, RMI. ARRW test series 1 flight would terminate with splashdown of the motor and inert payload into the BOA. The USAF preferred impact scenario for the ARRW test series 2 is Illeginni Islet, as it is the only location that meets the requirements of the Purpose of and Need for the Proposed Action. This EA/OEA only analyzes the environmental impacts from the ARRW test series 1 and 2 launch, overflight, and terminal impact in either the BOA or Illeginni Islet, RMI.

The environmental resource areas analyzed in this EA/OEA include water resources, geological resources, cultural resources, land use, airspace, noise, transportation and infrastructure, public health and safety, hazardous materials and waste, socioeconomics, environmental justice, visual resources, air quality, and biological resources. The study area for each resource analyzed may differ due to how the Proposed Action interacts with or impacts the resource. For instance, the study area for geological resources only includes the weapons impact footprint, whereas the noise study area is expanded to include areas that may be impacted by airborne and water transmitted noise.

1.4.1 Related Environmental Documentation

Key documents are sources of information incorporated by reference into this EA/OEA. These documents are considered to be key because they address similar actions, analyses, or impacts in the same region that may apply to this Proposed Action. CEQ guidance encourages incorporating documents by reference. Documents incorporated by reference in part or as a whole include:

- *Environmental Assessment Missile Impacts, Illeginni Island at the Kwajalein Missile Range, Kwajalein Atoll Trust Territory of the Pacific Islands*, 1977. This assessment addresses the probable environmental effects of missile impacts on Illeginni Islands District, Trust Territory of the Pacific Islands.
- *U.S. Army Kwajalein Atoll Supplemental Environmental Impact Statement (EIS)*, 1993. This Final Supplemental EIS evaluates the environmental impacts of two proposed actions at USAG-KA. The first proposed action is the types and levels of test activities, including test facilities and support services at USAG-KA. The second proposed action is the adoption of new environmental standards and procedures for U.S. Government activities at USAG-KA.

- *Environmental Assessment for Minuteman III Modification*, 2004. This EA documents the potential environmental impacts of (1) Minuteman III (MMIII) missile flight tests using modified reentry system hardware/software, in addition to the continuation of Force Development Evaluation flight tests; (2) deployment of new and modified reentry system hardware/software; and (3) deployment activities for new command and control console equipment. The locations covered in this EA include F.E. Warren Air Force Base (AFB), Wyoming; Hill AFB, Utah; Malmstrom AFB, Montana; Minot AFB, North Dakota; Vandenberg AFB, California; and USAG-KA, RMI.
- *Advanced Hypersonic Weapon Program Environmental Assessment*, 2011. This EA analyzes the impacts of launching a flight test vehicle from Pacific Missile Range Facility (PMRF), Kauai, Hawaii, using an existing Strategic Target System (STARS) with three stages. The payload on the STARS vehicle would fly to a land or ocean impact at USAG-KA/Ronald Reagan Ballistic Missile Defense Test Site (RTS) (on or near Illeginni Islet) in the RMI.
- *Hawaii-Southern California Training and Testing Activities Final Environmental Impact Statement/Overseas Environmental Impact Statement*, 2013. The Navy identified its need to support and conduct current, emerging, and future training and testing activities in the Hawaii-Southern California Study Area, which is made up of air and sea space off Southern California, around the Hawaiian Islands, and the air and sea space connecting them.
- *Advanced Hypersonic Weapon Flight Test 2 Hypersonic Technology Test Environmental Assessment*, 2014. This EA documents the demonstration flight test of a flight test vehicle launched from the Kodiak Launch Complex, using an existing three-stage STARS. Following booster separation, the test vehicle would fly to an impact site in the vicinity of Illeginni Islet at USAG-KA in the RMI.
- *Final Environmental Assessment/Overseas Environmental Assessment for Flight Experiment 1 (FE-1), 2017.* This assessment addresses the probable environmental effects of conducting Navy Flight Experiment 1 from PMRF on Kauai, Hawaii to Illeginni Islet, RTS, RMI.
- *Final Environmental Impact Statement / Overseas Environmental Impact Statement Point Mugu Sea Range, 2002*. This EIS analyzes the potential environmental consequences of proposed Theater Missile Defense testing and training as well as facility modernization at PMSR.

1.5 Relevant Laws and Regulations

The USAF has prepared this EA/OEA based on federal and state laws, statutes, regulations, and policies that are pertinent to the implementation of the Proposed Action, including the following:

- NEPA (42 USC §§ 4321-4370h), which requires an environmental analysis for major federal actions that have the potential to significantly impact the quality of the human environment
- CEQ Regulations for Implementing the Procedural Provisions of NEPA (40 CFR Parts 1500-1508)
- USAF Environmental Impact Analysis Process (32 CFR Part 989), which provides USAF policy for implementing CEQ regulations and NEPA
- Environmental Analysis of Army Actions (Army Regulation; AR 200-2), which provides Department of the Army procedures for implementing NEPA (32 CFR Part 651)
- Clean Air Act (CAA) (42 USC § 7401 et seq.)
- Clean Water Act (CWA) (33 USC § 1251 et seq.)
- Coastal Zone Management Act (CZMA) (16 USC § 1451 et seq.)
- National Historic Preservation Act (NHPA) (54 USC § 306108 et seq.)
- Endangered Species Act (ESA) (16 USC § 1531 et seq.)
- Marine Mammal Protection Act (MMPA) (16 USC § 1361 et seq.)
- Migratory Bird Treaty Act (MBTA) (16 USC §§ 703-712)
- Executive Order (EO) 11988, Floodplain Management
- EO 12088, Federal Compliance with Pollution Control Standards
- EO 12114, Environmental Effects Abroad of Major Federal Actions
- EO 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-income Populations
- EO 13045, Protection of Children from Environmental Health Risks and Safety Risks
- EO 13089, Coral Reef Protection
- EO 13834, Efficient Federal Operations
- Compact of Free Association Between the United States and the Republic of the Marshall Islands, which became effective on October 21, 1986, under Presidential Proclamation No. 5564 on November 3, 1986; and was amended pursuant to Public Law 108-188 – December 17, 2003; 17 STAT 2723
- Compact of Free Association Military Use and Operating Rights Agreement between the United States of America and the Marshall Islands, March 23, 2004
- U.S. Army Kwajalein Atoll Environmental Standards (UES) 15th Edition, June 2017

1.6 Public and Agency Participation and Intergovernmental Coordination

A project-specific Notice of Proposed Activity (NPA) and Document of Environmental Protection (DEP) were prepared and submitted to the UES Appropriate Agencies and to the RMI public for a 30-day review and comment period prior to production of the Draft EA/OEA. Substantive comments received from U.S. and RMI agencies on the Draft EA/OEA and their responses were incorporated into the Preliminary Final EA/OEA (See **Appendix A**).

The USAF coordinated or consulted with the U.S. Fish and Wildlife Service (USFWS), National Marine Fisheries Service (NMFS), and UES Appropriate Agencies regarding the Proposed Action, including RMI Environmental Protection Authority (RMIEPA), U.S. Environmental Protection Agency (USEPA), and the U.S. Army Corps of Engineers (USACE).

A notice of availability (NOA) was published, indicating when the document would be issued; where copies could be obtained or reviewed; the duration of the comment period; where comments should be sent; and location, date, and times regarding the Final EA/OEA and Draft FONSI. The NOA was published as follows:

- *The Kwajalein Hourglass (U.S. Army Garrison Kwajalein Atoll [USAG-KA])*
- *The Marshall Islands Journal*

Comments on the EA/OEA and FONSI were requested to be submitted on the project website or mailed to the following address:

U.S. Army Space and Missile Defense Command
Attention: SMDC-EN (David Fuller)
Post Office Box 1500
Huntsville, AL 35807-3801

In accordance with CEQ and Department of Defense (DOD) regulations for implementing NEPA, the USAF solicited comments on the Final EA/OEA and the Draft FONSI from interested and affected parties, from 8 June 2020 to 7 July 2020. Copies of the Final EA/OEA and Draft FONSI were placed in local repositories for public access and made available over the internet at https://arrwea.govsupport.us/. Those agencies, organizations, and repositories that were directly notified about the NOA or received a copy of the document are listed in **Appendix B**.

Following the public review period (as specified in the newspaper notice), the USAF will decide whether to sign the FONSI, which would allow the Proposed Action to be implemented, or to prepare an Environmental Impact Statement (EIS). If the USAF decides to sign the FONSI, the Final EA/OEA will include both the written comments (i.e., letters and electronic messages received) and their resolutions. The Final EA/OEA and FONSI will be accessible on the internet at https://arrwea.govsupport.us/.

2.0 Description of the Proposed Action and Alternatives

2.1 Proposed Action

The USAF ARRW system (**Figure 2-1**) program would consist of ARRW test series 1 and 2 flights designed to prove various aspects of the system's capabilities. ARRW flight tests will consist of all components required to demonstrate successful capabilities. The ARRW test series 1 and 2 would be carried externally on B-52 aircraft and released in-flight. After air-drop of the ARRW test series 1 over PMSR, the vehicle's motor, shroud and inert payload would splash down in the BOA.

After air-drop of the ARRW test series 2 within the BOA, the vehicle's solid rocket motor would ignite and the ARRW vehicle would travel over the BOA towards RTS at USAG-KA in the RMI. Once the motor is spent, the spent motor and shroud would fall into the BOA, and the payload would continue flight towards USAG-KA where it would impact at Illeginni Islet in Kwajalein Atoll. The Proposed Action entails pre-test preparation, aerial drop and ignition, flight tests, impact of the payload, and post-test activities.

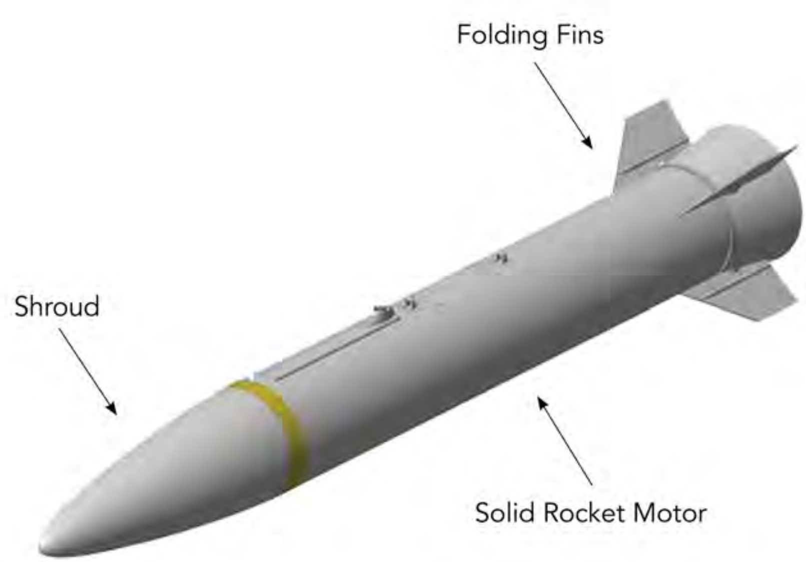

Figure 2-1. ARRW Weapon System

Table 2-1 presents characteristics of both the ARRW vehicle and payload system. The Proposed Action would occur within a reasonable time after signing of the FONSI, if approved. The inert payload system attached during the ARRW tests would be aluminum alloy. The aluminum payload body would reach temperatures at flight termination that would turn the structure molten, before splashing down into the BOA. Cursory buoyancy analysis shows that if there is no case breach during flight, the spent motor can float. Although floating debris is considered unlikely; there is a low probability that the spent motor could float on the ocean surface post-splashdown. No hazardous materials will be associated with the inert payload body.

Table 2-1. Vehicle and Payload Characteristics

Major Components	Glider, Protective Shroud, Exit Cone, Motor and Boron Potassium Nitrate (BKNO3) Pyrogen Igniter and Solid Propellant
Structure	ARRW weapon system weight not to exceed 2,268 kilograms (kg; 5,000 pounds [lb]), 589-centimeter (cm; 232-inch [in.]) length, and 66-cm (26-in.) diameter; carbon phenolic with metal shell, graphite and 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 1,633 kg (3,600 lb) of aluminized Hydroxyl Terminated Polybutadiene (HTPB)
Other	Small Class C (1.4) electro-explosive devices

2.2 Screening Factors

NEPA's implementing regulations provide guidance on the consideration of alternatives to a federally Proposed Action and require rigorous exploration and objective evaluation of reasonable alternatives. Only those alternatives determined to be reasonable and that meet the purpose and need require detailed analysis.

The alternatives for the ARRW test series 1 and 2 flight tests were derived through the following screening criteria/evaluation factors. Due to the ARRW system initiating from an aerial drop and inflight ignition point, screening and evaluation were limited to point of airdrop and solid rocket motor ignition, flight pattern, and impact location:

1. The on-land impact location must have the specialized infrastructure and personnel capable of conducting the ARRW test series 2 flights such that:
   a. Data such as pre-mission analyses, real-time performance data, and post-mission analyses can be analyzed in the required timeframe; and
   b. The number and type of equipment required to support the test (e.g., trailers, tractors, cranes, trucks, forklifts, and manlifts) are currently available or will be available when required.
2. The impact location must be available for conducting the test within the required timeframe.

   a. Capable of conducting test flights (with impact in the BOA) within a reasonable time period after completion of the EA/OEA; and
   b. Capable of conducting multiple test flights (with impact at Illeginni islet) within a reasonable period after completion of the EA/OEA; and
   c. Able to complete all documentation required to support/authorize the test prior to test flight (e.g., memorandum of agreement/memorandum of understanding [MOA/MOU], range request letter, range safety data package).
3. The impact location must be capable of providing required range safety, including explosive safety.
4. The impact location must meet security requirements.

Due to the ARRW test series 1 originating over PMSR and splashing down into the BOA, no screening criteria/evaluation factors were required.

2.3 Alternatives Carried Forward for Analysis

Based on the reasonable alternative screening factors and meeting the purpose and need for the Proposed Action, only the Preferred Alternative meets the program needs and is analyzed within this EA/OEA. Alternative 1 (Preferred Alternative) includes:

1. ARRW test series 1 air-drop from a B-52 platform over PMSR, inflight ignition of the vehicle's solid rocket motor, flight of the vehicle with inert payload westward, and splashdown into the BOA; and

2. ARRW test series 2 air-drop from a B-52 platform within the BOA, inflight ignition of the vehicle's solid rocket motor, and flight of the vehicle with attached payload towards RTS at USAG-KA in the RMI. Separation of the spent motor and the shroud would occur over the BOA, and the payload would continue flight towards USAG-KA where it would impact at Illeginni Islet in Kwajalein Atoll.

Per USAF EIAP, 32 CFR Part 989, the No Action Alternative must be considered for this action. The No Action Alternative would not meet the purpose and need for the Proposed Action; therefore, as required by NEPA and EIAP, the No Action Alternative is carried forward for analysis in this EA/OEA and provides a baseline for measuring the environmental consequences of the action alternatives.

2.4 ARRW Proposed Action (Alternative 1)

2.4.1 Pre-test Operations

2.4.1.1 Pre-test Operations (Test Series 1)

No land impact is associated with the ARRW test series 1 flight tests. Therefore, no pre-test activities have been identified.

2.4.1.2 Pre-test Operations (Test Series 2)

USAG-KA and RTS support of the ARRW test series 2 flight tests would include base support, range safety, flight test support, and test instrumentation. The USAF LCMC would ensure that all relevant personnel associated with the Proposed Action are fully briefed on the best management practices (BMP) and the requirement to adhere to them for the duration of the Proposed Action. All activities would comply with the UES (USASMDC/ARSTRAT 2018). A project-specific DEP has been prepared in support of the ARRW test series 2 flight tests, in order to identify requirements and limitations.

For the Proposed Action at Illeginni Islet, activities would include several vessel round-trips and helicopter trips. Additionally, raft-borne sensors may be deployed and recovered on both (or either) the ocean and lagoon sides. There would also be increased human activity on Illeginni Islet that would involve up to 15 persons over a 2-month period. Heavy equipment placement and use would occur at times.

For at least 8 weeks preceding each ARRW test series 2 flight, Illeginni Islet would be surveyed by qualified persons for sea turtles, sea turtle nesting activity, and sea turtle nests. If possible, these persons would also inspect the area within days of the flight test. On-site personnel would report any observations of sea turtles or sea turtle nests on Illeginni Islet to the USAG-KA Environmental Engineer to provide to NMFS and USFWS.

During travel to and from Illeginni Islet, and during potential raft deployment, ship personnel would monitor for marine mammals and sea turtles to avoid potential vessel strikes. Vessel operators would adjust speed or potential raft deployment based on expected animal locations, densities, and/or lightning and turbidity conditions. Any marine mammal or sea turtle sightings during overflights or ship travel would be reported to the USAG-KA Environmental Engineer, the RTS Range Directorate, and the Flight Test Operations Director for consideration in approving the launch. Vessel operations around Illeginni Islet would only occur when weather and sea conditions are acceptable for safe travel. Vessel operations would not involve any intentional ocean discharges of fuel, toxic wastes, or plastics and other solid wastes that could potentially harm marine life.

On Illeginni Islet, the impact area would be searched for black-naped tern (*Sterna sumatrana*) nests and chicks prior to any pre-flight equipment mobilization. Any discovered nests would be covered with an A-frame structure per current USFWS guidance. The area would be monitored to ensure no black-naped tern nests are disturbed when heavy equipment is placed on the islet. To prevent birds from nesting on the support equipment after initial setup, the equipment would be appropriately covered with tarps or other materials and “scare” techniques (e.g., scarecrows, mylar ribbons, and/or flags) would be used on or near the equipment.

The ARRW system would be integrated with the launch platform while on the flightline at Edwards AFB or Barksdale AFB. Prior to flight a series of ground tests would be performed to ensure safe operation of the vehicle. These would include functional checkouts and electromagnetic interference tests. After the completion of testing the launch platform would be returned to its standard configuration, on the Edwards AFB or Barksdale AFB flightline. All pre-test and ground operations have been covered by existing categorical exclusion (CATEX) authorizations (AF 813 Form).

2.4.2 Flight Test

2.4.2.1 Flight Test (Test Series 1)

ARRW test series 1 flight testing activities would include the air-drop over PMSR, ignition of the vehicle’s solid rocket motor, and the vehicle with inert payload traveling westward over the BOA. Once the motor is spent, the spent motor, shroud, and inert payload would splash down into the BOA of the Pacific Ocean (**Figure 1-2**). Cursory aero analysis showed the motor is unstable at all Mach, and cursory buoyancy analysis shows that if there is no case breach then the spent component can float. Floating debris is considered unlikely; however, there is a low probability that the spent component could float on the ocean surface post-splashdown.

2.4.2.2 Flight Test (Test Series 2)

ARRW test series 2 flight testing activities would include the air-drop within the BOA, ignition of the vehicle’s solid rocket motor, and the vehicle with attached payload traveling towards RTS at USAG-KA in the RMI. Once the motor is spent, the spent component and shroud would separate and fall into the BOA (Pacific Ocean), (**Figure 1-2**), and the payload would continue flight towards USAG-KA where it would impact at Illeginni Islet in Kwajalein Atoll. Due to the ARRW test series 2 being an aerial drop device, the BOA accounts for all potential shroud and component drop locations. The ARRW system would fly towards Illeginni Islet from the aerial drop point, with the flight path avoiding populated locations (Hawaiian Islands, etc.). Cursory aero analysis showed the motor is unstable at all Mach, and cursory buoyancy analysis shows that if there is no case breach then the spent component can float. Floating debris is considered unlikely; however, there is a low probability that the spent component could float on the ocean surface post-splashdown. The payload would fly toward the pre-designated target site at Illeginni Islet.

The ARRW test series 2 payload would incur a land impact at USAG-KA Illeginni Islet (**Figure 1-3**) within an impact zone 290 meters (m) by 137 m (950 feet [ft] by 450 ft) on the northwestern end of the islet. The mission planning process will aid in avoidance, to the maximum extent possible, of all potential risks to environmentally significant areas. The actual impact zone size and location (asphalt pad, field, etc.) on Illeginni Islet will be based on range safety requirements and chosen as part of the mission analysis process. Range safety issues would also be part of selecting the impact scenario.

2.4.3 Flight Safety

2.4.3.1 Flight Safety (Test Series 1)

If the ARRW test series 1 vehicle were to deviate from its course during the flight test, 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 component with inert payload to terminate flight and fall towards the ocean. The FTS would be designed to prevent any debris from falling into any marine protected area. No inhabited land areas would be subject to unacceptable risks of falling debris.

2.4.3.2 Flight Safety (Test Series 2)

If the ARRW test series 2 vehicle were to deviate from its course or should other problems occur during flight that might jeopardize public safety, the onboard FTS would be activated. This action would initiate a destruct charge causing the ARRW test series 2 vehicle to fall towards the ocean and terminate flight. The FTS would be designed to prevent any debris from falling into any protected area. No inhabited land areas would be subject to unacceptable risks of falling debris. The ARRW test series 2 flight path would avoid inhabited areas, as per U.S. range operation standards and practices. In accordance with U.S. range operation standards, the risk of casualty (probability for serious injury or death) from falling debris for an individual of the general public cannot exceed 1 in 1,000,000 during a single flight test or mission (Range Commanders Council [RCC] 2017).

To ensure the safe conduct of flight testing, a Mid-Atoll Corridor Impact Area has been established across the mid-section of the Atoll. When a test is to occur in this area, a number of strict precautions are taken to protect personnel. Such precautions may consist of evacuating nonessential personnel and sheltering all other personnel remaining within the Mid-Atoll Corridor. Notices to Airmen (NOTAMs) and Notices to Mariners (NTMs) are published and circulated in accordance with established procedures to provide warning to persons, including native Marshallese citizens, concerning any potential hazard areas that should be avoided. For public notification within USAG-KA before any flight test occurs, standard practice is to distribute an announcement from Kwajalein Island regarding the upcoming mission that is then provided to the public in Marshallese and English on the Roller and in radio announcements. Additionally, notices of upcoming missions are provided by the U.S. Embassy to the Government of the RMI (GRMI) for the GRMI to distribute. A fact sheet describing the project and the environmental controls would be prepared in English and Marshallese and would be provided at locations on Ebeye and Kwajalein Island. Radar and visual sweeps of the hazard area are accomplished immediately prior to test flights to ensure the clearance of non-critical personnel.

2.4.4 Sensor Coverage

2.4.4.1 Sensor Coverage (Test Series 1 and 2)

The aircraft flight path would be in a westward trajectory, with the B-52 platform departing from Edwards AFB, California or Barksdale AFB, Louisiana. Aerial drop for the ARRW test series 1 flights would occur over PMSR traveling westward over the BOA. Aerial drop of the ARRW test series 2 flights would occur within the BOA, east of Illeginni, with the projected flight path continuing west to Illeginni Islet. A series of sensors would overlap coverage of the flights from aerial drop and ignition of the solid rocket motor to impact in the BOA or at Illeginni Islet. Due to the sensitivity of the ARRW test series 1 and 2 flight paths and range, depiction of the array of radar and sensor stations is not included in this EA/OEA.

Sensors would include:

- Various sea-based sensors would be used for this mission, including the potential for the Missile Defense Agency Pacific Collector, the Mobile At-Sea System (MATSS) and the Kwajalein Mobile Range Safety System (KMRSS) onboard the U.S. Motor Vessel *Worthy*.
- Additional airborne and waterborne sensors on military or commercial aircraft are not planned as part of the ARRW test series 2 flight tests. Other agencies might collect data for their own purposes, but these extra sensors are speculative and outside the scope of this EA/OEA.
- Identified sensors are existing programs and would be scheduled for use based on availability.

2.4.5 Terminal Phase Preparations and Operations

2.4.5.1 Terminal Phase Preparations and Operations (Test Series 1)

The ARRW test series 1 components would splash down into the BOA, and no terminal phase operations are anticipated. Floating debris is considered unlikely; however, there is a low probability that the component could float on the ocean surface post-splashdown. There would be a visual verification of the splashdown area to determine if any visible, floating debris is present. Any floating debris would be recovered and disposed of properly. During visual inspection of the splashdown area, the presence of any injured or dead marine mammals, or their absence, would be recorded and reported to the USAG-KA Environmental Engineer and NMFS.

2.4.5.2 Terminal Phase Preparations and Operations (Test Series 2)

Following aerial drop and ignition in the BOA, the ARRW test series 2 vehicle would fly over the BOA towards USAG-KA. Once the motor is spent, the payload would separate and the spent components would fall into the BOA. Floating debris is considered unlikely; however, there is a low probability that the spent components could float on the ocean surface post-splashdown. There would be a visual verification of the component splashdown area to determine if any visible, floating debris is present. Any floating debris would be recovered and disposed of properly. During visual inspection of the splashdown area, the presence of any injured or dead marine mammals, or their absence, would be recorded and reported to the USAG-KA Environmental Engineer and NMFS. The ARRW test series 2 payload would continue flight towards USAG-KA, making impact at the northwestern end of Illeginni Islet (**Figure 2-2**). The targeted area for the payload would be selected to minimize impacts to identified wildlife habitats. A reef or shallow water impact is not part of the Proposed Action, would be unintentional, and is unlikely. However, some debris may enter the shallow water environment due to breakup upon impact.

Figure 2-2. Potential Land Impact Area on Illeginni Islet

The proposed terminal impact point for the ARRW test series 2 payload would be in the non-forested area to avoid affecting the bird habitat. A crater would form as a result of this impact and leave debris that would need to be recovered. Post-test debris recovery and cleanup operations on Illeginni Islet would cause some short-term disturbance to small areas of migratory bird habitat and possibly to coral reef habitat. After each test, debris would be recovered, and the crater filled for a land impact. Visible debris would be removed following any unintentional shallow water impact.

2.4.6 Post-Launch Operations

2.4.6.1 Post-Launch Operations (Test Series 1)

Due to the BOA splashdown of ARRW test series 1 components, post launch operations would be limited to a visual verification of the splashdown area to determine if any visible, floating debris is present. Floating debris is considered unlikely; however, there is a low probability that the spent components could float on the ocean surface post-splashdown. If debris is found, the debris field would be approached by ship and debris would be recovered manually. Since the BOA consists of very deep waters, only surface materials would be recovered. During visual inspection of the splashdown area, the presence of any injured or dead marine mammals, or their absence, would be recorded and reported to the USAG-KA Environmental Engineer and NMFS.

2.4.6.2 Post-Launch Operations (Test Series 2)

Post ARRW test series 2 launch operations in the BOA would be limited to a visual verification of component splashdown areas to determine if any visible, floating debris is present. Floating debris is considered unlikely; however, if found, the debris field would be approached by ship and debris would be recovered manually. Only surface materials would be recovered. During visual inspection of the splashdown area, the presence of any injured or dead marine mammals, or their absence, would be recorded and reported to the USAG-KA Environmental Engineer and NMFS.

Prior to recovery and cleanup actions at the Illeginni Islet impact zone, payload recovery personnel would first survey the impact site for any residual explosive materials. Post-test recovery operations at Illeginni Islet would require the manual cleanup and removal of any debris, including hazardous materials. Site recovery and clean-up would be performed for land or shallow water impact in a manner to minimize further harm to biological resources. Post-survey monitoring would also be conducted to observe any impacts to adult black-naped terns of their nests. Results of the monitoring would be reported to the USAG-KA Environmental Engineer to provide to the USFWS.

When feasible, within 1 day after the land impact test at Illeginni Islet, USAG-KA environmental staff would survey the islet and the near-shore waters for any injured wildlife, damaged coral, or damage to sensitive habitats. For recovery and rehabilitation of any injured migratory birds or sea turtles found at Illeginni Islet, USFWS and NMFS would be notified to advise on best care practices and qualified biologists would be allowed to assist in recovering and rehabilitating any injured sea turtles found. During inspections of the islet and near-shore waters, USAG-KA environmental staff would assess any sea turtle mortality. Any impacts to biological resources would be reported to the appropriate agencies, with USFWS and NMFS offered the opportunity to inspect the impact area to provide guidance on mitigations.

Post-test recovery operations at Illeginni Islet would require the manual cleanup and removal of all visible ARRW test debris. The impact area would be washed down to stabilize disturbed soil. Following removal of all experiment items and any remaining debris from the target site, the impact crater would be backfilled and, if necessary, repairs made to surrounding structures. Any accidental spills from support equipment operations would be contained and cleaned up. All waste materials would be returned to Kwajalein Island for proper disposal in the United States. Following cleanup and repairs to the Illeginni site, soil and groundwater samples would be collected at various locations around the impact area and tested for tungsten alloy.

The ARRW test debris would include tungsten for ballast, etc., in accordance with **Table 2-1**. However, due to the sensitivity of the data, exact quantities of tungsten in the ARRW test series 2 ballast are not available. To provide an appropriate conservative assessment, a quantity of up to 79 kg (175 lb) of tungsten alloy is used for the environmental impact analysis.

No residual ARRW test series 2 debris within the lagoon and offshore areas is expected following impact; however, a recovery team would be sent to inspect the shallow water locations as soon as range safety clears the area. Payload recovery/cleanup operations and removal of floating debris in the lagoon and ocean reef flats, within 150 to 300 m (500 to 1,000 ft) of the shoreline, would be conducted similarly to land operations when tide conditions and water depth permit. Personnel would also manually recover ARRW test series 2 debris from surrounding shallow waters (less than 55 m [180 ft] deep), as necessary and reasonably possible.

Vehicle impacts from other tests have occurred within the Kwajalein Atoll lagoon, on and in the vicinity of Illeginni Islet, and in the deep-water impact zones near RTS, USAG-KA. These and other actions within the geographical scope of this EA/OEA have undergone environmental analysis and review, which is provided in **Section 1.4.1,** related environmental documentation, and the analyses all resulted in FONSIs.

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 NMFS and USFWS would also be invited to inspect the site as soon as practical after the test. The inspectors would assess any damage to coral and other natural and biological resources and, in coordination with USAF LCMC, USAG-KA and RTS representatives, decide on any response measures that may be required. Recovery operations on the reef flat would be conducted similarly to land operations when tide conditions and water depth permit. A backhoe would be used to excavate the crater. Excavated material would be screened for debris, and the crater would be backfilled with reef materials ejected around the rim of the crater.

Should the ARRW test series 2 vehicle inadvertently impact in the deeper waters of the Atoll lagoon (up to approximately 55 m [180 ft]), a dive team from USAG-KA or RTS would be brought in to conduct underwater searches. Using a ship for recovery operations, the debris field would be located and certified divers in scuba gear would attempt to recover the debris manually. Digital imagery of benthic resources in the impact area would be collected and forwarded to NMFS and USFWS, along with the location coordinates. Injured and/or dead marine mammals and sea turtles would be noted and reported to the USAG-KA Environmental Engineer and NMFS. In general, payload recovery operations would not be attempted in deep waters (greater than 55 m [180 ft]) on the ocean side of the Atoll.

2.4.7 Avoidance, Minimization, and Mitigation Measures

The USAF would implement several discretionary measures to minimize the impacts of the Proposed Action on the environment. These discretionary mitigation measures include:

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

reported to appropriate test and USAG-KA personnel for consideration in approval of the test flights and to USFWS and NMFS;

- Personnel would report any observations of sea turtles or sea turtle nests on Illeginni to appropriate test and USAG-KA personnel to provide to USFWS and NMFS;
- The impact area would be searched for black-naped tern nests and chicks prior to any pre-flight equipment mobilization, and any nests would be covered with an A-frame structure per USFWS guidance (**Appendix A**);
- To prevent birds from roosting on the support equipment or in the impact area on Illeginni, equipment would be appropriately covered with tarps or other materials and/or “scare” techniques (e.g., scarecrows, mylar ribbons, and/or flags) would be used on or near the equipment and in the impact area;
- To avoid impacts on coral heads in waters near Illeginni Islet, sensor rafts would not be located in waters less than 4 m (13 ft) deep and would not utilize anchors or moorings;
- When feasible, within 1 day after the land impact test at Illeginni Islet, USAG-KA environmental staff would survey the islet and the near-shore waters for any injured wildlife, damaged coral, or damage to sensitive habitats. Any impacts to biological resources would be reported to the appropriate agencies, with USFWS and NMFS offered the opportunity to inspect the impact area to provide guidance on mitigations;
- Although unlikely, any dead or injured marine mammals or sea turtles sighted by post-flight personnel would be reported to the USAG-KA Environmental Office and SMDC, which would then inform NMFS and USFWS. USAG-KA aircraft pilots otherwise flying in the vicinity of the impact and test support areas would also similarly report any opportunistic sightings of dead or injured marine mammals or sea turtles;
- For recovery and rehabilitation of any injured migratory birds or sea turtles found at Illeginni Islet, USFWS and NMFS would be notified to advise on best care practices, and qualified biologists would be allowed to assist in recovering and rehabilitating any injured sea turtles found;
- If an inadvertent impact occurs on the reef, reef flat, or in shallow waters less than 3 m (10 ft) deep, an inspection by project personnel would occur within 24 hours. Representatives from NMFS and USFWS would also be invited to inspect the site as soon as practical after the test. The inspectors would assess any damage to coral and other natural and biological resources and, in coordination with USAF, USAG-KA, and RTS representatives, decide on any response measures that may be required;
- Debris recovery and site cleanup would be performed for land or shallow water impacts. To minimize long-term risks to marine life, all visible project-related debris would be recovered during post-flight operations, including debris in shallow lagoon or ocean waters by range divers. In all cases, recovery and cleanup would be conducted in a manner to minimize further impacts on biological resources;
- At Illeginni Islet, should any missile components or debris impact areas of sensitive biological resources (i.e., sea turtle nesting habitat or coral reef), USFWS and NMFS

biologists would be allowed to provide guidance and/or assistance in recovery operations to minimize impacts on such resources. To the greatest extent practicable, when moving or operating heavy equipment on the reef during post-test clean up, protected marine species including invertebrates would be avoided or effects to them would be minimized. This may include movement of these organisms out of the area likely to be affected; and

- During post-test recovery and cleanup, should personnel observe endangered, threatened, or other species requiring consultation moving into the area, work would be delayed until such species were out of harm's way or leave the area.

In accordance with the Final Biological Opinion (BO; **Appendix C**) provided by NMFS on 30 July 2019, the following reasonable and prudent measures would be 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 Incidental Take Statement to apply (NMFS 2019).

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

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

1. To meet reasonable and prudent measure 1 above, the USAF shall ensure that their personnel comply fully with the BMP and conservation measures identified in the Biological Assessment (BA; USAF and USASMDC 2019) and below.
   a. The USAF shall ensure that all relevant personnel associated with this project are fully briefed on the BMP and the requirement to adhere to them for the duration of this project.
   b. In the event the payload impact that affects the reef at Illeginni, the USAF 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 15.24 cm (6 in.) 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 15.24 cm (6 in.) 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 secure in-place should be relocated to suitable habitat where it is not likely to become mobilized.

c. In the event of the payload impact affects the reef at Illeginni, the USAF shall require its personnel to reduce impacts on top shell snails.
   i. Rescue and reposition any living top shell snails that are buried or trapped by rubble.
   ii. Relocate to suitable habitat, any living top shell snails that are in the path of any heavy equipment that must be used in the marine environment.

d. In the event the payload land impact affects the reef at Illeginni, the USAF shall require its personnel to reduce impact on clams.
   i. Rescue and reposition any living clams that are buried or trapped by rubble.
   ii. Relocate to suitable habitat, any living clams that are in the path of any heavy equipment that must be used in the marine environment.

2. To meet reasonable and prudent measure 2 above:
   a. The USAF shall assign appropriately qualified personnel to record all suspected incidences of take of any UES-consultation species.
   b. The USAF shall utilize digital photography/videography to record any UES-consultation species found injured or killed in or near the ocean target areas and/or at Illeginni Islet. As practicable: (1) Photograph all damaged corals and/or other UES-consultation species that may be observed injured or dead; (2) Include a scaling device (such as a ruler) in photographs to aid in the determination of size; and (3) Record the location of the photograph.
   c. In the event the payload impact affects the reef at Illeginni, the USAF shall require its personnel to survey the ejecta field for impacted corals, top shell snails, and clams. The personnel shall also be mindful of any other UES-consultation species that may have been affected.
   d. Within 60 days of completing post-test clean-up and restoration, provide photographs/videos and records to the USAG-KA environmental office. USAG-KA and NMFS biologists would 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 would provide a report to NMFS. 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.

Reinitiating formal consultation would be 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 the NMFS Final BO;
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 the NMFS Final BO; or
4. A new species is listed, or critical habitat designated that may be affected by the action.

2.5 No Action Alternative

USAF LCMC has been directed by the U.S. DOD to perform multiple ARRW test series 1 and 2 flights within a reasonable timeframe from the completion of the EA/OEA and signing of the FONSI. Flight tests must meet certain mission and project objectives to provide the data desired by DOD. In accordance with USAF EAIP (32 CFR Part 989), the USAF must analyze reasonable alternatives to the proposed action and the "no action" alternative in all EAs, as fully as the proposed action alternative. For the purposes of this EA/OEA, adoption of the No Action Alternative will dictate that the ARRW system test activities will not take place.

Under the No Action Alternative, the Proposed Action would not occur, and the USAF would not pursue the ARRW program flight tests.

2.6 Alternatives Considered but not Carried Forward for Detailed Analysis

No other Alternatives have been considered for this action. No other Alternatives meet the purpose and need for the Proposed Action and satisfy the reasonable alternative screening factors presented in **Section 2.2**.

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3.0 Affected Environment

This chapter describes the environmental conditions that could be affected by the Proposed Action and No Action Alternatives. In compliance with NEPA, CEQ, and 32 CFR Part 775 guidelines, the information and data presented are commensurate with the importance of the potential impacts to provide the proper context for evaluating such impacts. Sources of data used and cited in the preparation of this chapter include past EAs and EISs, environmental resource documents and other related environmental studies, installation and facility personnel, and regulatory agencies.

The Affected Environment may include descriptions of the affected environment for air quality, water resources, geological resources, cultural resources, land use, infrastructure, transportation, biological resources, airspace, noise, public health and safety, hazardous materials and wastes, environmental justice, and visual resources, as applicable. Only resource areas with potential impacts are analyzed in detail in this EA/OEA. All other resource areas mentioned are expected to have no impacts.

3.1 Edwards Air Force Base

Edwards AFB, California, has been identified as a potential departure point for B-52 aircraft carrying the ARRW system (test series 1 and 2). Impacts associated with movement of materials and weapons systems, storage and air operations from Edwards AFB, are addressed and covered by the *Environmental Assessment for Increasing Routine Flight Activities, Edwards Air Force Base, California* (AFFTC 2009) and the *Environmental Assessment for the Continued Use of Restricted Area R-2515, Edwards AFB* (AFFTC 1998). The *Environmental Assessment for Increasing Routine Flight Activities, Edwards Air Force Base, California* includes departure of the B-52 and flight activities to the aerials drop point. As such, no potential impacts analysis to resources associated with transport, storage or departure of the ARRW system or B-52 aircraft from Edwards AFB, California, are assessed within this ARRW EA/OEA. The transit of the weapon system (aircraft departure to aerial release point) from Edwards AFB, is not assessed in this document.

3.2 Barksdale Air Force Base

Barksdale AFB, Louisiana, has also been identified as a departure point for B-52 aircraft carrying the ARRW system (test series 1 and 2). Impacts associated with movement of materials and weapons systems, storage and ground operations at Barksdale AFB, are addressed and covered by the *Environmental Assessment Addressing Construction and Operation of a Weapons Storage and Maintenance Facility, Barksdale Air Force Base, Louisiana* (USAF 2017). As such, no potential impacts analysis to resources associated with transport, storage or ground operations associated with the ARRW system or B-52 aircraft from Barksdale AFB, Louisiana, are assessed within this ARRW EA/OEA. The transit of the weapon system (aircraft departure to aerial release point) from Barksdale AFB is not assessed in this document.

3.3 Point Mugu Sea Range

PMSR, part of the NAWCWD Point Mugu, is located off the Pacific Coast of Southern California and supports test and evaluation of sea, land, and air weapons systems. PMSR provides a safe volume of air and sea space in which to conduct controlled tests (U.S. Navy 2002). PMSR comprises 93,680 km^2 (36,000 mi^2) of ocean area. PMSR extends from less than 5.6 km (3 nm) to more than 370 km (200 nm) off the California coastline. The aerial drop and vehicle ignition for flight tests could potentially occur within the boundaries of PMSR, with the flight azimuth heading in a westerly direction, away from land.

This section includes detailed descriptions of noise, public health and safety, hazardous materials and wastes, air quality, and biological resources. Potential impacts to all other resource areas within this geographical area are considered to be negligible or non-existent, so they were not analyzed in detail in this EA/OEA. Additionally, the ARRW test series 2 vehicle will be launched within the BOA, so its potential impacts to the above-mentioned resource areas are discussed in **Section 3.4**.

3.3.1 Water Resources

There are no groundwater or surface water resources within PMSR that would be affected by the ARRW test series 1 tests. No impacts would occur to water resources within the over-ocean flight corridor from the ARRW test series 1 tests. Potential impacts to water resources associated with public health and safety and hazardous wastes and materials are addressed in **Section 3.3.8,** and **Section 3.3.9,** respectively.

3.3.2 Geological Resources

There would be no drilling, mining, or construction in PMSR. There would be no impacts to geological resources at PMSR from the ARRW test series 1 tests. No impacts to geological resources or marine sediments from the ARRW test series tests are expected**.**

3.3.3 Cultural Resources

San Nicolas Island (SNI) within PMSR has been completely surveyed for archaeological resources. The multiple investigations conducted over the previous 100 years have revealed more than 530 prehistoric sites and 48 historic sites (U.S. Navy 2002). Historic sites on SNI include the remnants of fishing and ranching activities that occurred on the island from the 1850s until the Navy took ownership of the island in 1933. Fishing camps on SNI are typically found on the northwestern and southeastern tips of the island, while evidence of ranching activities is generally encountered on the terraces above Naval Facilities Engineering Command (NAVFAC) Beach

(U.S. Navy 2002). Much of SNI has been inventoried for historic-era buildings and structures. These investigations have resulted in the identification of one building (N138) that has been determined eligible for the National Register of Historic Places (NRHP). However, due to the ARRW vehicle originating from an aerial drop, there would be no impacts to cultural resources.

3.3.4 Land Use

No ground activities resulting in changes to land use would occur from the ARRW test series 1 tests. The flight path of the ARRW test series 1 tests would avoid populated land masses. There would be no land use changes caused by the ARRW test series 1 tests, and therefore, no impacts to land use are anticipated within PMSR.

3.3.5 Airspace

No new special use airspace would be required, expanded, or altered for the ARRW test series 1 tests. Local airport operations would not be affected. Commercial and private aircraft would be notified through Federal Aviation Administration (FAA) NOTAM in advance of the launch as part of their routine operations. Flight operations would be conducted in accordance with Western Range procedures (USAF 2010). There would be no impacts to airspace from the ARRW test series 1 tests.

3.3.6 Noise

This discussion of noise includes the types or sources of noise and the associated sensitive receptors in the human environment. Noise sources in PMSR are transitory and widely dispersed. PMSR covers very little land area. Ambient noise levels at PMSR are slightly greater because of higher levels of equipment, vehicle, and aircraft operations; there are several aircraft flights per week there, including military and commercial jet aircraft.

Flight test vehicles can generate sonic booms during ignition and/or shortly afterwards. The sound of a sonic boom resembles rolling thunder and is produced by a shock wave that forms at the nose and at the exhaust plume of a missile when it travels faster than the speed of sound. These shock waves produce an audible sonic boom when they reach the ground.

A sonic boom would occur in PMSR as a result of the Proposed Action, particularly when the ARRW test series 1 vehicle exceeds the speed of sound.

3.3.6.1 Regulatory Setting

Federal, state, and local limits on noise are in place to protect people from potential hearing impairment. These regulations also help to limit impacts of noise, such as the disruption of activities or quality of life.

PMSR is required to comply with federal noise standards and guidelines set forth in the Noise Control Act of 1972 (42 USC § 4901 et seq.), but as a part of the DOD it is not subject to state and local noise ordinances.

DOD initiated the Air Installations Compatible Use Zones (AICUZ) Program in response to urban development around military installations and community concerns about aircraft noise. The 2015 AICUZ Study for Point Mugu discusses and presents noise associated with aircraft operations, including average noise levels, noise abatement/flight procedures, noise complaints, sources of noise, airfield-specific noise contours, and analysis of changes from the historic, baseline, and prospective noise contours.

3.3.6.2 Region of Influence

Airborne noise in PMSR is created by subsonic and supersonic flight activity of aircraft, aerial targets, and missiles. Airborne noise introduced by surface vessels is negligible compared to noise introduced by low-flying aircraft and targets. The Region of Influence (ROI) for airborne noise includes all areas of PMSR where aircraft or aero-vehicle noise is emitted, especially areas near shore that may be affected by the Proposed Action. Because the Proposed Action would be performed at high altitude and offshore in PMSR, the affected environment is relegated to biological resources. See a discussion of these affected environments in **Section 3.3.14** and **Section 4.1.15**.

3.3.7 Transportation and Infrastructure

Transportation services and infrastructure would be unaffected by the ARRW test series 1 tests. Public NOTAMs and NTMs would be issued along the flight path, to protect the safety of aircraft and vessels. The ARRW test series 1 aerial drop, ignition and westward flight would occur in this ROI; however, due to proposed elevation of the vehicle there would be no impacts to transportation or infrastructure at PMSR.

3.3.8 Public Health and Safety

Public health and safety issues include hazards inherent to flight operations, missile tests, operation of air and sea vessels, and training exercises. The safety policy of PMSR is to observe every reasonable precaution in the planning and execution of all operations which occur on PMSR to prevent injury to people and damage to property.

If the ARRW test series 1 vehicle were to deviate from its course or should other problems occur during aerial drop and solid rocket motor (SRM) ignition that might jeopardize public safety, the onboard FTS would be activated. This action would initiate a destruct charge causing the ARRW test series 1 vehicle to fall into the identified BOA and terminate flight. The FTS would be designed to prevent debris from falling into any protected area. No inhabited land areas would be subject to unacceptable risks of falling debris. There would be no impacts from the ARRW test series 1 flights to public health and safety along the flight path from PMSR over the BOA.

3.3.8.1 Regulatory Setting

Range safety measures ensure protection to Installation personnel, ships, and aircraft operating in the downrange areas potentially affected by flight tests.

Commercial, private, and military air and sea traffic in caution areas designated for specific flight tests or missions, and inhabitants near a flight path, are notified of potentially hazardous operations. An NTM and a NOTAM are transmitted to appropriate authorities to clear traffic from caution areas and to inform the public of impending missions. The warning messages describe the time, the area affected, and safe alternate routes.

3.3.8.2 Region of Influence

The ROI for public health and safety includes all areas of PMSR where PMSR-related activity occurs. Specific to the ARRW test series 1, the ROI includes areas near shore that may be affected by the Proposed Action. Because the Proposed Action would be performed at high altitude, the affected environment would be limited to above the ocean.

Were the FTS to be activated during aerial drop and SRM ignition, the public's health and safety would not be jeopardized because it would be over the ocean, and every attempt to notify air and sea traffic will have been made to ensure the area is cleared before the flight tests.

3.3.9 Hazardous Materials and Wastes

Hazardous material is defined as any hazardous or toxic substance or chemical. This material can cause substantial damage because of its quantity, concentration, physical, chemical, or infectious characteristics. When missiles, munitions, and targets are used for their intended purpose, component hazardous materials are considered hazardous constituents because they may have certain chemical constituents or have certain toxicity, ignitability, corrosivity, or reactivity characteristics.

Table 2-1 describes the ARRW test series 1 and 2 mechanical and chemical characteristics. After aerial drop of the ARRW test series 1 vehicle over PMSR, $BKNO_3$ Pyrogen igniter and solid propellant would be burned as part of the start of the ARRW propulsion system. Approximately 1,633 kg (3,600 lb) of aluminized HTPB would then be burned as propellent during flight. The ARRW test series 1 propulsion system would commence over PMSR and continue in a westward trajectory, with the ARRW test series 1 vehicle impacting into the BOA. The ARRW test series 1 vehicle has two onboard battery powered systems (28-volt and 150-volt batteries), both adhering to Military Standard 1760 power source requirements. Considering the small quantities of hazardous materials contained in the batteries and the dilution and mixing capabilities of the ocean waters and atmosphere at PMSR, the battery materials that may be potentially released should be of little consequence to any receptors. Because the Proposed Action would be performed at high altitude, the affected environment is relegated to air quality, global atmosphere, and climate change. A discussion of the effect of the igniter and propellent in the atmosphere can be found in **Section 4.2.13**.

3.3.9.1 Regulatory Setting

Hazardous materials are defined by the U.S. Department of Transportation as a substance or material that is capable of posing an unreasonable risk to health, safety, or property when transported in commerce and has been so designated.

Hazardous wastes are controlled by the Resource Conservation and Recovery Act (RCRA; 42 USC § 6901 et seq.); however, the ARRW test series 1 flight would commence over PMSR and continue in a westward trajectory over the BOA, then would impact in the BOA. The ARRW test series 1 tests would result in trace (*de minimis*) amounts of hazardous waste as a result of the Proposed Action. RCRA 42 USC § 6924 (section (q)) allows for an exemption of hazardous waste used as fuel if the waste is destroyed and removed sufficiently such that protection of human health and environment is assured. The latter describes the Proposed Action.

3.3.9.2 Region of Influence

After aerial drop over PMSR, the ARRW test series 1 propulsion system $BKNO_3$ Pyrogen igniter and aluminized HTPB propellent would ignite and the ARRW would fly west across PMSR through the identified BOA. The ROI of hazardous waste and materials at PMSR is the 93,200 km^2 (36,000 mi^2) area of PMSR.

3.3.10 Socioeconomics

There is no permanent resident population at SNI or within PMSR. Therefore, there would be no impacts to socioeconomics from the ARRW test series 1 flights.

3.3.11 Environmental Justice

PMSR does not include any population centers; therefore, there would be no disproportionate impacts from the ARRW test series 1 flights to minority populations and low-income populations as defined under EO 12898.

3.3.12 Visual Resources

There would be no changes to and, therefore, no impacts to the visual aesthetics at PMSR from the ARRW test series 1 flights.

3.3.13 Air Quality, Greenhouse Gases, and Climate Change

Primary pollutants, such as carbon monoxide (CO), sulfur dioxide (SO_2), lead (Pb), and some suspended particulate matter (PM_{10}), are emitted directly into the atmosphere from emission sources. Secondary pollutants, such as ozone (O_3), nitrogen dioxide (NO_2), and some particulates, are formed through atmospheric photochemical reactions that are influenced by meteorology, ultraviolet light, and other atmospheric processes.

Because the Proposed Activity for the ARRW test series 1 tests is comparatively small in scale next to the variety of tests and exercises performed at PMSR, the amount of emissions would be considered negligible. There would be no change to air emissions at PMSR from the Proposed Action. Aerial drop and ignition of the ARRW test series 1 vehicle at PMSR would not affect air quality, greenhouse gases, or climate change at PMSR.

3.3.13.1 Regulatory Setting

Air quality is defined by ambient air concentrations of specific pollutants determined by the USEPA to be of concern with respect to the health and welfare of the general public. Six major pollutants of concern are CO, SO_2, NO_2, O_3, PM_{10}, and Pb. Under the CAA the USEPA has established National Ambient Air Quality Standards (NAAQS) for these pollutants, called “criteria pollutants.” The NAAQS establish ambient concentrations of criteria pollutants that are considered protective of public health and welfare.

The California Air Resources Board (CARB) subsequently established the more stringent California Ambient Air Quality Standards (CAAQS). Areas within California in which ambient air concentrations of a pollutant are higher than the state and/or federal standard are considered to be in nonattainment for that pollutant. PMSR lies within Ventura County; which is classified as a severe nonattainment area for the federal standard for O_3, and a nonattainment area for the state standards for PM_{10} and O_3.

Because of the potential global effects of testing rockets over the Pacific Ocean and through the Earth’s atmosphere, this EA/OEA considers the environmental effects on the global environment in accordance with the requirements of EO 12114, *Environmental Effects of Major Federal Actions*; Department of Defense Directive (DODD) 6050.7, *Environmental Effects Abroad of Major Department of Defense Actions;* and EO 13834, *Efficient Federal Operations*, which outlines policies to ensure that federal agencies evaluate and improve their energy efficiency. This section describes the baseline conditions within PMSR that may be affected by the proposed ARRW test series 1 tests.

3.3.13.2 Air Quality

The stratosphere, which extends from 10 km (6 miles [mi]) to approximately 50 km (30 mi) in altitude, contains the Earth’s ozone layer (NOAA 2019). The ozone layer plays a vital role in absorbing harmful ultraviolet radiation from the sun. Over the last 20 years, anthropogenic (human-made) gases released into the atmosphere—primarily chlorine related substances—have threatened ozone concentrations in the stratosphere that filter harmful ultraviolet sunlight. Such materials include chlorofluorocarbons (CFC), which have been widely used in electronics and refrigeration systems, and the lesser-used halons, which are extremely effective fire extinguishing agents. Once released, the motions of the atmosphere mix the gases worldwide until they reach the stratosphere, where ultraviolet radiation releases their chlorine and bromine components.

Through global compliance with the 1987 Montreal Protocol on Substances that Deplete the Ozone Layer and amendments, the worldwide production of CFCs and other ozone-depleting substances has been drastically reduced and banned in many countries. A continuation of these compliance efforts is expected to allow for a slow recovery of the ozone layer (World Meteorological Organization 2016).

Atomic chlorine produced from emissions of hydrogen chloride during high-temperature afterburning reactions in the exhaust plume of solid propellant rocket motors can contribute to overall global chlorine loading, which contributes to long-term ozone depletion. Stratospheric hydrogen chloride is diffused through the troposphere and dissipates with a half-life of about 2.3 years; however, hydrogen chloride from rocket emissions could have longer lifetimes because part of the emission occurs at atmospheric levels above the stratosphere. Studies have shown that aluminum oxide, which is emitted from the rocket exhaust as solid particles, could contribute to ozone depletion via activation of chlorine in the atmosphere (Spencer 1996). Emissions of nitrogen oxides produced in the exhaust plume of rockets can also contribute to stratospheric ozone depletion.

According to the 2002 PMSR EIS/Overseas EIS (OEIS), aircraft operating within PMSR with emissions above 914 m (3,000 ft) were considered to be above the atmospheric inversion layer and would not have an impact on local air quality. The ARRW (test series 1) Proposed Action is anticipated to occur around 12.2 km (40,000 ft) and would therefore not impact local air quality at PMSR.

Impacts of the ARRW test series 1 on air quality, global warming and ozone depletion in the atmosphere have also been considered as part of cumulative impacts in **Chapter 5.0**. Because the Proposed Activity states ARRW test series 1 tests would be spread out over a reasonable period of time, the amount of emissions is considered negligible. There would be no change to air emissions at PMSR from the Proposed Action. Aerial drop and ignition of the ARRW test series 1 at PMSR would not be expected to affect air quality.

3.3.13.3 Greenhouse Gases

The CEQ final guidance (CEQ 2016) recommended that agencies use projected greenhouse gas (GHG) emissions as a proxy for assessing potential climate change effects or include a qualitative analysis when quantification is not reasonably available when preparing NEPA documents. The guidance is primarily focused on projects that have large air quality implications and emphasizes a netting approach to GHG analysis. Although not specifically identified in the final 2016 guidance, the prior draft guidance included a reference point of 25,000 metric tons per year (27,558 tons per year) of carbon dioxide equivalent emissions for discussion and disclosure of such emissions from larger federal actions that may have appreciable GHG emissions (CEQ 2014). This threshold was carried forward to determine if additional quantitative analysis would be required for the ARRW test series 1 tests within this EA/OEA.

Because the Proposed Activity is for ARRW test series 1 tests, the amount of emissions would be considered negligible. There would be no change to greenhouse gas base levels at PMSR from the Proposed Action. Aerial drop and ignition of the ARRW test series 1 tests at PMSR would not be expected to affect greenhouse gases.

3.3.13.4 Climate Change

Current global climate changes are scientifically attributable to global warming occurring from GHG emissions. The global annual temperature has increased at an average rate of 0.07 degrees Celsius (°C) (0.13 degrees Fahrenheit [°F]) per decade since 1880 and at an average rate of 0.17°C (0.31°F) per decade since 1970. The warmest global average temperatures on record have all occurred within the past 15 years, with the warmest years being 2010, 2013, 2014, and 2015 (NOAA 2016). The USAF, through DoD directive, is poised to support climate-changing initiatives globally, while preserving military operations, sustainability, and readiness by working, where possible, to reduce GHG emissions.

Sea level rise from global warming is primarily ascribed to water flowing into the sea from melting freshwater ice on land and the expansion of sea water as it warms. Tracked by satellites (1993–2016) and as measured along coast lines (1870–2000), according to the (Nerem et al. 2018) the current rate of sea level rise is 3.41 millimeters (mm; 0.13 in) per year.

ARRW test series 1 test emissions would be considered negligible. There would be no change to current global climate at PMSR from the Proposed Action. Aerial drop and ignition of the ARRW test series 1 tests at PMSR would not be expected to affect climate change.

3.3.13.5 Region of Influence

Many of the air basins in the coastal region of southern California are nonattainment areas for federal O_3 standards (U.S. Navy 2002). This is due to several factors, including increases in population that generate increased industrial and automotive activity; episodes of air stagnation; warm periods with low, strong inversions; and transport of pollutants from neighboring areas. On average, PMSR generally experiences frequent northwesterly surface winds. However, such conditions are interrupted by: (1) cool season storms (with southerly winds) and periods of dry offshore northeast winds (Santa Ana winds); (2) mainly warm season coastal eddies with southeast winds over the inner waters; and (3) alternating land/sea breeze circulations as one approaches the mainland coast. Due to the influence of the continent on the overall wind flow, in addition to the eddies and other complicating factors nearshore, there is a strong tendency for the relatively persistent northwesterly winds in the outer Sea Range to become more westerly as the air approaches the mainland (U.S. Navy 2002).

3.3.14 Biological Resources

Biological resources described in this section are defined as terrestrial and marine flora and fauna and the habitats within which they occur. Plants, algae, and other primary producers and their communities are referred to as vegetation, and animal species are referred to as wildlife. Habitat is defined as the biotic and abiotic conditions that support plant or animal species. Marine is broadly defined as occurring in ocean waters. Based on the potential stressors that would result from the Proposed Action, terrestrial flora and fauna at PMSR would not be impacted by the Proposed Action and are not discussed further in this EA/OEA. The following sections describe the regulatory setting for evaluation of biological resources as well as the current state of biological resources in the PMSR ROI.

3.3.14.1 Regulatory Setting

For the purposes of this EA/OEA, special status species in PMSR are those species listed as threatened or endangered under the ESA, species protected under the MMPA, and species protected under the MBTA. The effects on biological resources are evaluated in accordance with the requirements of these acts and DOD procedures for implementation.

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

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

Migratory Bird Treaty Act (MBTA). Birds, both migratory and most native-resident bird species, are protected under the MBTA (16 USC §§ 703-712), and their conservation by federal agencies is mandated by EO 13186 (Migratory Bird Conservation). Under the MBTA it is unlawful by any means or in any manner, to pursue, hunt, take, capture, kill, attempt to take, capture, or kill, [or] possess migratory birds or their nests or eggs at any time, unless permitted by regulation. Under EO 13186, federal agencies must evaluate the effects of actions on migratory birds with emphasis on species of concern, which were later defined as birds of conservation concern (BCC) by the USFWS (USFWS 2008). Birds listed as BCC are species with the highest conservation priority which without additional conservation actions are likely to become candidates for listing under the ESA (USFWS 2008). The 2003 National Defense Authorization Act gave the Secretary of the Interior authority to prescribe regulations to exempt the Armed Forces from the incidental taking of migratory birds during authorized military readiness activities. The final rule authorizing the DOD to take migratory birds in such cases includes a requirement that the Armed Forces must confer with the USFWS to develop and implement appropriate conservation measures to minimize or mitigate adverse effects of the proposed action if the action will have a significant negative effect on the sustainability of a population of a migratory bird species.

Magnuson-Stevens Fishery Conservation and Management Act (MSA). The MSA (16 USC § 1801 et seq.) provides for the conservation and management of the fisheries. Under the MSA, essential fish habitat (EFH) consists of the waters and substrate needed by fish to spawn, breed, feed, or grow to maturity. An EFH may include U.S. waters within EEZs (seaward boundary out to a distance of 370 km [200 nm]) and covers all fish species within in a fishery management unit (50 CFR §600.805). Under the MSA, an adverse effect means any impact that reduces quality and/or quantity of EFH (50 CFR § 600.810). Adverse effects may include direct or indirect physical, chemical, or biological alterations of the waters or substrate and loss of, or injury to, benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce the quality and/or quantity of EFH (50 CFR § 600.810). EFH and its geographic boundaries are defined by regional fisheries management councils. Federal agencies must evaluate the effects of an action on EFH and must consult with NMFS on actions that may adversely affect EFH (67 Federal Register [FR] 2343 [17 January 2002]).

3.3.14.2 Region of Influence

The ROI for biological resources at PMSR includes the area subject to effects of the Proposed Action, specifically those areas subject to elevated noise levels from vehicle ignition and overflight. No increased human activity or vessel traffic in PMSR would be anticipated as part of the ARRW test series 1 tests. While not planned or expected, an accident during ARRW test series 1 test air-drop or ignition is possible and would result in splashdown of the ARRW vehicle. Therefore, marine biological resources at PMSR in general are described as well. Based on the potential location of ARRW test series 1 air-drop (at least 93 km [50 nm] from land) and anticipated noise levels, terrestrial flora and fauna in PMSR are not expected to be affected by the Proposed Action and are not discussed further in this EA/OEA. Biological resources in the ROI, including special status species and environmentally sensitive habitats, are described in detail below.

Biological resources at PMSR were described in the PMSR EIS/OEIS (U.S. Navy 2002). More recently, biological resources in the region were described in the Hawaii-Southern California Training and Testing (HSTT) EIS/OEIS (U.S. Navy 2018) which includes some area of overlap with PMSR near San Nicolas Island.

For the purposes of this document, PMSR is defined by the extent shown in **Figure 1-1,** from approximately 31° to 36°North (°N) and from 118° to 124°West (°W). PMSR encompasses 93,200 km^2 (36,000 mi^2) (of Pacific Ocean off the Coast of California that includes regions of complex bathymetry and provides diverse habitats for a variety of marine life (U.S. Navy 2002). A diversity of benthic habitats exist in PMSR with abundant soft substrates, such as sandy beaches, shelves, and slopes, along the mainland and the offshore islands (U.S. Navy 2002). Hard substrates, such as rocky intertidal areas, shallow subtidal reefs, deep rock reefs, and kelp beds, are also common along the coasts of the mainland and islands (U.S. Navy 2002). At depths greater than 30 m (100 ft), approximately three percent of the sea floor consists of rubble and rocky outcrops with, sand and gravel substrate interspersed between these rocky areas on the continental shelf (U.S. Navy 2002). The shelves of the Channel Islands in PMSR as well as the offshore Santa Rosa-Cortez Ridge, and Tanner and Cortez banks, primarily have substrate of base rock and rocky outcrops that may be covered with a thin layer of sediment (U.S. Navy 2002). At depths over 500 m (1,640 ft) in PMSR, hard substrates are predominant and benthic habitats include sea mounts and man-made structures (U.S. Navy 2002).

The diversity of benthic and pelagic habitats in PMSR provides habitat for a large abundance and diversity of marine vegetation and wildlife including many special status species (see **Table 3-1**). The current status of biological resources in the PMSR portion of the ROI, including special status species, is evaluated based on the best available data and summarized in the marine vegetation and marine wildlife subsections. Due to the limited potential for effects to marine vegetation and wildlife from the Proposed Action (evaluated in **Section 4.1**), only general descriptions of marine vegetation and wildlife with the potential to occur in the ROI are included here, rather than detailed species descriptions. More detailed species descriptions for special status species can be found in the PMSR EIS/OEIS (U.S. Navy 2002) and the HSTT EIS/OEIS (U.S. Navy 2018).

Marine Vegetation

Marine vegetation in PMSR and the Southern California Bight (the broad embayment south of Point Conception) consists primarily of phytoplankton and algae. Phytoplankton such as diatoms, dinoflagellates, blue-green algae, and coccolithophores (U.S. Navy 2018) are photosynthetic primary producers that provide the base of many marine food chains in the ROI. These organisms occur in the water column in the photic zone (are with sunlight), from the surface to approximately 200 m (660 ft; U.S. Navy 2018).

Macroalgae and some vascular plants also provide important primary production and habitat structure in shallow waters of the ROI along the mainland and around the Channel Islands. More than 700 species and varieties of seaweed (such as coralline and other red algae, brown algae, and green algae), seagrasses, and canopy-forming kelp occur along the California coast (U.S. Navy 2018). Kelp forests occur on hard, rocky substrates (U.S. Navy 2002) and provide the basis for a diverse and abundant communities of algal species, invertebrates, fish, and marine mammals.

There are no known ESA listed, proposed, or candidate vegetation species in the ROI.

Marine Wildlife

A diversity of marine wildlife occurs in PMSR and the ROI including invertebrates, fish, sea turtles, seabirds, and marine mammals. As discussed above, due to the limited potential for effects to marine wildlife from the ARRW test series 1 and test series 2 flight tests (evaluated in **Section 4.1**), only general descriptions of marine wildlife with the potential to occur in the ROI are included here, rather than detailed species descriptions. More detailed species descriptions for special status species including threats and current population size can be found in the PMSR EIS/OEIS (U.S. Navy 2002) and the HSTT EIS/OEIS (U.S. Navy 2018).

Marine Mammals. Several marine mammal species have been documented in PMSR (**Table 3-1**) including cetaceans, pinnipeds, and southern sea otters (*Enhydra lutris nereis*). All marine mammal species in the ROI are protected under MMPA, and seven species are listed under the ESA. Of the cetaceans with the potential to occur in PMSR (**Table 3-1**), nine species can be found in moderate to high numbers for all or part of the year (U.S. Navy 2002). These species include the Dall's porpoise (*Phocoenoides dalli*), Pacific white-sided dolphin (*Lagenorhynchus obliquidens*), Risso's dolphin (*Grampus griseus*), bottlenose dolphin (*Tursiops truncatus*), short-beaked and long-beaked common dolphins (*Delphinus delphis* and *D. capensis*), northern right whale dolphin (*Lissodelphis borealis*), Cuvier's beaked whale (*Ziphius cavirostris*), and gray whale (*Eschrichtius robustus*; U.S. Navy 2002). Other cetacean species (**Table 3-1**) are only found in PMSR in small numbers or are considered rare in PMSR with only occasional sightings or strandings. Five ESA-listed cetacean species have the potential to occur in PMSR: the humpback whale (*Megaptera novaeangliae*), sperm whale (*Physeter macrocephalus*), blue whale (*Balaenoptera musculus*), fin whale (*B. physalus*), and sei whale (*B. borealis*). All of the ESA-listed cetacean species, as well as killer whales (*Orcinus orca*) and bottlenose dolphins are considered "depleted" stocks under the MMPA.

Table 3-1. Special Status Marine Mammal Species known to Occur or with the Potential to Occur in the PMSR ROI.

Common Name	Scientific Name	Federal Listing Status	Relative Abundance in PMSR	Habitat Preference
Cetaceans				
Minke whale	*Balaenoptera acutorostrata*	MMPA	Uncommon	Shelf and offshore
Sei whale	*B. borealis*	E, MMPA-Depleted	Rare	Offshore
Bryde's whale	*B. edeni*	MMPA	Rare and Seasonal	Offshore
Blue whale	*B. musculus*	E, MMPA-Depleted	Uncommon	Coastal and Offshore
Fin whale	*B. physalus*	E, MMPA-Depleted	Uncommon	Slope and offshore
Baird's beaked whale	*Berardius bairdii*	MMPA	Rare	Slope and pelagic
Long-beaked common dolphin	*Delphinus capensis*	MMPA	Uncommon	Coastal to 50 nm offshore
Short-beaked common dolphin	*D. delphis*	MMPA	Common	Coastal to 300 nm offshore
Gray whale [1]	*Eschrichtius robustus*	MMPA	Rare	Coastal and offshore
Pygmy killer whale	*Feresa attenuata*	MMPA	Rare and Seasonal	Coastal and offshore
Short-finned pilot whale	*Globicephala macrorhynchus*	MMPA	Uncommon	Offshore and shallow waters
Risso's dolphin	*Grampus griseus*	MMPA	Common	Offshore and shelf
Pygmy sperm whale	*Kogia breviceps*	MMPA	Rare	Slope and pelagic
Dwarf sperm whale	*K. sima*	MMPA	Rare	Shelf
Pacific white-sided dolphin	*Lagenorhynchus obliquidens*	MMPA	Common	Deep shelf, slope, and offshore waters
Northern right whale dolphin	*Lissodelphis borealis*	MMPA	Common	Slope
Humpback whale	*Megaptera novaeangliae*	E[2], MMPA-Depleted	Uncommon	Nearshore
Hubbs' beaked whale	*Mesoplodon carlhubbsi*	MMPA	Rare	Pelagic
Blainville's beaked whale	*M. densirostris*	MMPA	Rare	Pelagic
Ginkgo-toothed beaked whale	*M. ginkgodens*	MMPA	Rare	Pelagic
Stejneger's beaked whale	*M. stejnegeri*	MMPA	Rare	Pelagic
Perrin's beaked whale	*M. perrini*	MMPA	Rare	Pelagic
Pygmy beaked whale	*M. peruvianus*	MMPA	Rare	Pelagic
Killer whale	*Orcinus orca*	MMPA-Depleted	Uncommon	Widely distributed

Common Name	Scientific Name	Federal Listing Status	Relative Abundance in PMSR	Habitat Preference
Harbor porpoise	*Phocoena phocoena*	MMPA	Rare	Coastal
Dall's porpoise	*Phocoenoides dalli*	MMPA	Common	Shelf, slope, and offshore
Sperm whale	*Physeter macrocephalus*	E, MMPA-Depleted	Uncommon	Pelagic
Striped dolphin	*Stenella coeruleoalba*	MMPA	Rare	100-300 nm offshore
Rough-toothed dolphin	*Steno bredanensis*	MMPA	Rare	Nearshore waters
Bottlenose dolphin	*Tursiops truncatus*	MMPA-Depleted	Rare	Coastal, shelf, slope, and offshore
Cuvier's beaked whale	*Ziphius cavirostris*	MMPA	Uncommon	Pelagic
Pinnipeds				
Guadalupe fur seal	*Arctocephalus townsendi*	T, MMPA-Depleted	Rare	Forages up to 240 nm from rookery
Northern fur seal	*Callorhinus ursinus*	MMPA-Depleted	Common	Forages 1 to 74 nm from rookery
Steller sea lion[3]	*Eumetopias jubatus*	MMPA	Very Rare	Forages up to 72 nm from haulouts
Northern elephant seal	*Mirounga angustirostris*	MMPA	Common	Forages in the open ocean
Harbor seal	*Phoca vitulina*	MMPA	Common	Forages < 3 nm from shore, occasionally to 27 nm
California sea lion	*Zalophus californianus*	MMPA	Common	Forages 1-54 nm from rookery
Mustelids				
Southern sea otter	*Enhydra lutris*	T, MMPA-Depleted	Uncommon	Coastal areas with kelp beds, waters up to 330 ft deep

Sources: U.S. Navy 2018, U.S. Navy 2002, Hanser et al. 2017
Abbreviations: MMPA = Marine Mammal Protection Act; E = ESA endangered; T = ESA threatened
[1] The gray whales in the ROI are likely from unlisted Eastern Populations. It is possible, but unlikely, that a small (but unknown) number of these whales are from the Western DPS.
[2] The eastern north Pacific DPS of humpback whales is listed as endangered.
[3]The Steller sea lions in the PMSR ROI would be from the eastern DPS which is not currently listed under the ESA.

Of the six species of pinnipeds with the potential to occur in PMSR, the four most abundant species are the harbor seal (*Phoca vitulina*), northern elephant seal (*Mirounga angustirostris*), California sea lion (*Zalophus californianus*), and northern fur seal (*Callorhinus ursinus*; U.S. Navy 2002). These four species are known to breed on land within PMSR on the Channel Islands (U.S. Navy 2002). While these pinniped species breed, haulout, and pup on land, they forage in marine habitats. Northern elephant seals have large concentrations on San Miguel and San Nicolas Islands (U.S. Navy 2018) and forage primarily in the open ocean (Robinson et al 2012). Northern fur seals and California sea lions also forage primarily in deeper waters and can regularly be found in offshore waters of PMSR (U.S. Navy 2002). Harbor seals also forage within PMSR but are generally found in shallower, nearshore waters (U.S. Navy 2002). These four pinniped species are not listed as endangered or threatened under the ESA; however, like other marine mammal species they are protected under the MMPA. Guadalupe fur seals (*Arctocephalus townsendi*) are listed as threatened under the ESA as well as under the California Endangered Species Act and are considered depleted under the MMPA. The Guadalupe fur seal is considered rare in PMSR; however, these seals are known to use San Miguel Island for haulout and breeding (U.S. Navy 2018). Guadalupe fur seals have also been observed on Santa Barbara, San Nicolas, and San Clemente Islands (U.S. Navy 2018). This species primarily forages within the U.S. and Mexico EEZs (Marine Mammal Center 2018); however, these fur seals are known to forage up to 589 km (240 nm) from land (Gallo-Reynoso et al. 2008). The Steller sea lion (*Eumetopias jubatus*) has two distinct population segments (DPSs), the ESA-endangered western DPS (west of Cape Suckling in Alaska) and the delisted eastern DPS. Steller sea lions are considered very rare in PMSR (U.S. Navy 2002, U.S. Navy 2018) but any sea lions that do occur in the area would very likely be from the eastern DPS.

The southern sea otter is listed as a threatened species under the ESA and is considered MMPA depleted. The primary range of southern sea otters is north of PMSR; however, some sea otters occur as far south as Santa Barbara seasonally, and a small experimental population has been translocated to San Nicolas Island (U.S. Navy 2018, U.S. Navy 2002). Approximately 92 southern sea otters and 12 pups were counted in the most recent surveys at San Nicolas Island (U.S. Navy 2018). Aside from the population at San Nicolas Island, few sea otters are expected to occur within PMSR because of their preference for relatively shallow (approximately 20 m [66 ft] deep) coastal waters (U.S. Navy 2002).

Potential threats to marine mammals in PMSR include ingestion of marine debris, entanglement in fishing nets or other marine debris, collision with vessels, loss of prey species due to new seasonal shifts in prey species or overfishing, excessive noise above baseline levels in a given area, chemical and physical pollution of the marine environment, parasites and diseases, and changing sea surface temperatures due to global climate change (NOAA 2018a).

Sea Turtles. Four species of sea turtles have the potential to occur in the PMSR ROI (**Table 3-2**), all of which are listed under the ESA. In general, green (*Chelonia mydas*) and olive ridley (*Lepidochelys olivacea*) turtles occur in shallow nearshore areas of PMSR while leatherback (*Dermochelys coriacea*) and juvenile loggerhead (*Caretta caretta*) turtles occur in a wide range of water depths (U.S. Navy 2002). There are no known sea turtle nesting locations in the vicinity of the PMSR ROI (U.S. Navy 2002).

Table 3-2. Special Status Species Reptiles and Fish known to Occur or with the Potential to Occur in the PMSR ROI.

Common Name	Scientific Name	Federal Listing Status	Likelihood of Occurrence in PMSR
Sea Turtles			
Loggerhead turtle	*Caretta caretta*	E[1]	L
Green turtle	*Chelonia mydas*	T[2]	L
Leatherback turtle	*Dermochelys coriacea*	E	L
Olive ridley turtle	*Lepidochelys olivacea*	T, E[3]	U
Fish			
Oceanic giant manta ray	*Manta birostris*	T	P
Coho salmon – Central California Coast ESU	*Oncorhynchus kisutch*	T	U
Steelhead	*O. mykiss*		
California Central Valley ESU		T	U
South-central California Coast ESU		T	P
Southern California Coast ESU		E	L
Chinook salmon	*O. tshawytscha*		
California Coastal ESU		T	P
Central Valley spring-run ESU		T	L
Sacramento River winter-run ESU		E	U
Scalloped hammerhead	*Sphyrna lewini*	E[4]	U

Abbreviations: ESU = Evolutionarily Significant Unit; E = ESA endangered; T = ESA threatened; L = Likely; P = Potential; U = Unlikely.

[1] North Pacific Ocean DPS.

[2] The green turtle is currently listed based on DPSs. Green turtles in the ROI likely belong to the East Pacific DPS and are listed as threatened (Seminoff et al. 2015).

[3] The olive ridley turtle is listed as threatened throughout its range except for the Mexican Pacific Coast nesting population which is listed as endangered. Some olive ridley turtles in the ROI may be from this east Pacific Coast nesting population (NMFS and USFWS 2007a, NMFS and USFWS 2014).

[4] Any scalloped hammerheads in the PMSR ROI would likely be from the Eastern Pacific Ocean DPS which is listed as endangered under the ESA (Miller et al. 2014).

Each sea turtle species has unique life history characteristics that result in different patterns of distribution and abundance in the Pacific Ocean. Green and loggerhead turtles primarily use coastal habitats as adults or large juveniles; however, these turtles use open ocean habitats as hatchlings and juveniles (Polovina et al. 2000, Dutton et al. 2008, NMFS and USFWS 2013b). Loggerhead and green turtles may be encountered in PMSR year-round, but the highest frequency of occurrence is during summer (U.S. Navy 2002). Green turtles are likely to occur in the PMSR ROI (U.S. Navy 2002) where individuals spend much of their time resting and foraging in shallow, nearshore waters (Hanser et al. 2017). Green turtles are also known to migrate through deeper waters of the Pacific (Hanser et al. 2017), sometimes crossing entire ocean basins (NMFS and USFWS 2007c). Green turtles in the PMSR ROI are likely from the East Pacific DPS which is listed as threatened under the ESA, although some mixing may occur among turtle population segments (Seminoff et al. 2015). The North Pacific Ocean DPS of loggerhead turtles is listed as ESA-endangered, and juvenile loggerheads may occur in PMSR year-round but are more common in the summer months (U.S. Navy 2002). Loggerhead turtle hatchlings and early juveniles live in the open ocean before moving to nearshore foraging habitats close to their birth area (Musick and Limpus 1997). They may use the same nearshore habitat as juveniles or may move among different areas before settling in an adult coastal foraging habitat (Godley et al. 2003). Adult loggerheads are reported to be rare in PMSR any time of year (U.S. Navy 2002).

Leatherback and olive ridley turtles spend the majority of the non-breeding portion of their life cycles in the open ocean (NMFS and USFWS 2013c, NMFS and USFWS 2014). Leatherbacks are more temperate in distribution, extending to waters as far north as the Gulf of Alaska (NMFS and USFWS 2013c), while olive ridleys are found in tropical waters (NMFS and USFWS 2014). Leatherbacks, which are ESA-listed endangered throughout their range, will rarely be encountered in PMSR during winter but are common during summer (U.S. Navy 2002). Olive ridley turtles have a more tropical distribution and are rarely observed in PMSR or other waters off southern California (U.S. Navy 2002). Critical habitat for the leatherback turtle has been designated (see **Figure 3-1**) and is discussed in the “Environmentally Sensitive Habitats” subsection below. Olive ridley turtles in the eastern Pacific are nomadic migrants which swim large distances over vast ocean areas in search of food (NMFS and USFWS 2007a). While olive ridleys are considered unlikely in the PMSR ROI, any olive ridleys in this area could be from the ESA-endangered Mexican Pacific Coast nesting population or from other nesting populations in the Pacific which are ESA-threatened.

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

Fish. Fish are vital components of the marine ecosystem and have great ecological and economic importance in the ROI. The wide variety of marine habitats in the ROI support a great diversity and abundance of fish. PMSR includes benthic fish habitats at a variety of depths as well as epipelagic and mesopelagic fish habitats (U.S. Navy 2002). At least 481 species of fish are known to inhabit the Southern California Bight (U.S. Navy 2002) and many of these likely occur in PMSR. Epipelagic fish in PMSR include species such as northern anchovy (*Engraulis mordax*), Pacific sardine (*Sardinops sagax caeruleus*), Pacific mackerel (*Scomber japonicus*), Pacific bonito (*Sarda chiliensis*), yellowtail (*Seriola lalandi*), and swordfish (*Xiphias gladius*; U.S. Navy 2002). Commercial fisheries are important in the ROI and the California Department of Fish and Wildlife (CDFW) reports commercial fish landing in California waters each year. In the report for 2017 (CDFW 2018) the largest catches (by weight) in the Santa Barbara area were of Pacific mackerel, sablefish (*Anoplopoma fimbria*), shortspine thornyhead (*Sebastolobus alascanus*), Pacific bonito, Pacific sardine, California halibut (*Paralichthys californicus*), and white seabass (*Atractoscion nobilis*; CDFW 2018).

Five species of ESA-listed fish have the potential to occur in the PMSR ROI (**Table 3-2**). Most of these fish are considered rare at PMSR and are unlikely to occur in the ROI; however, some ESA-listed Evolutionarily Significant Units (ESUs) of salmon and steelheads are likely to occur seasonally in the ROI.

The oceanic giant manta ray (*Manta birostris*) is listed as threatened under the ESA. This species inhabits tropical, subtropical, and temperate waters and is largely found offshore in oceanic waters near productive coastlines (Miller and Klimovich 2016). Oceanic mantas are considered very rare in PMSR but are known to occur off the California coast on occasion (Larese and Coan 2008). Oceanic giant manta ray have been observed as bycatch in the California drift gillnet fishery targeting swordfish and thresher sharks (*Alopias* spp.) in very low numbers (14 between 1990 and 2006) and only during El Nino events (Larese and Coan 2008, Miller and Klimovich 2016).

The current range of the Eastern Pacific DPS of scalloped hammerhead sharks (*Sphyrna lewini*; ESA-endangered) extends north to southern California (Miller et al. 2014). PMSR is just north of the current occupied range of the species, but the historical distribution of scalloped hammerhead likely extended into the area (Miller et al. 2014). Scalloped hammerheads are considered unlikely to occur in PMSR, but their occasional occurrence in the ROI is possible.

While the abundance and distribution of salmonids in the ROI is largely unknown, a letter from NMFS regarding the PMSR EIS (U.S. Navy 2002) indicated that seven ESA-listed ESUs of three salmonid species may occur in PMSR (**Table 3-2**). A study by Bellinger et al. (2015) further clarified which chinook salmon (*Oncorhynchus tshawytscha*) ESUs were likely to be in the region (**Table 3-2**). These anadromous fish ESUs spawn in waters of the west coast of California but may occur in the ROI during the marine phase of their life cycles. The density and distribution of salmonids in the ROI likely varies yearly, seasonally, with ocean conditions, and with prey density.

Coho salmon (*Oncorhynchus kisutch*) of the Central California Coast ESU spawn in rivers as far south as Santa Cruz (NMFS 2016). After hatching, young coho salmon generally remain in freshwater rivers and streams for 18 months before transitioning to marine habitats of the Pacific (Stout et al. 2012). During their approximately 18-month marine phase (Stout et al. 2012), coho salmon migrate slowly along the coast and are more commonly found in coastal and inland waters than further offshore (Quinn and Myers 2005). Coho salmon are known to occur in coastal waters as far south as Monterey Bay but tend to be found near their area of origin (Weitkamp and Neely 2002). There is no known evidence that these coho salmon migrate as far south as PMSR and they are considered unlikely to occur in PMSR.

Steelhead (*Oncorhynchus mykiss*) from three ESA-listed ESUs have the potential to occur in the PMSR ROI (**Table 3-2**); California Central Valley ESU, South-Central California ESU, and Southern California Coast ESU (U.S. Navy 2002 Appendix G). The anadromous forms of this species spend up to 7 years in fresh water before moving to the ocean where they spend up to 3 years in saltwater prior to returning to spawn (NMFS 2004, Quinn and Myers 2005). This species is able to spawn more than once and some types are known to move between freshwater and saltwater habitats each year (NMFS 2004, Quinn and Myers 2005). Juvenile North American steelhead migrate long distances to offshore ocean waters and are known to range across almost the entire North Pacific south to 40°58'N (Quinn and Myers 2005). Freshwater habitat for the California Central Valley ESU (ESA-threatened) includes rivers that empty into ocean at San Francisco Bay (71 FR 834 [05 January 2006]). Fish from this ESU may occur in PMSR but are unlikely and if present would likely be present in low numbers. The South-central California Coast ESU (ESA-threatened) occurs in freshwater rivers from Monterey Bay to south of San Luis Obispo (71 FR 834 [05 January 2006]). Southern California Coast ESU steelhead (ESA-endangered) occur in rivers from Santa Maria south to San Diego (71 FR 5248 [05 January 2006]). Steelhead from these ESUs, especially the Southern California ESU, likely occur in PMSR at least during some seasons but at unknown densities.

On the west coast of North America, chinook salmon historically spawned in fresh water from southern California north to Point Hope, Alaska in the Chukchi Sea (NMFS 2004). These anadromous fish have two life history types, one “stream-type” that remains in freshwater for a year or more before migrating to the ocean and a second “ocean-type” that migrates to the ocean within their first year (NMFS 2004). The ocean-type is known to have coastal-oriented, ocean migrations where they are found predominantly in coastal ocean waters before returning to freshwater habitats to spawn during (NMFS 2004). The stream-type populations undertake more extensive off-shore ocean migrations at-sea between their freshwater life history stages (NMFS 2004). In general, the at-sea abundance of chinook salmon (regardless of type), is higher in coastal waters than in offshore waters (Quinn and Myers 2005, Myers et al. 2005). Individual fish from six stocks of chinook salmon have the potential to occur in the PMSR ROI (Bellinger et al. 2015). The majority of chinook salmon samples taken at-sea of the coast from Monterey Bay south were from California central valley stocks (fall-run, winter-run, and spring-run) with some from the California coastal, Northern California/Southern Oregon coastal, and Rogue stocks (Bellinger et al. 2015). Therefore, chinook salmon present in the PMSR ROI may include individuals from two ESA-threatened ESUs; the California Coast ESU and the Central Valley Spring-run ESU. While the NMFS suggested that individuals from the endangered Sacramento

River winter-run ESU may occur in the PMSR ROI, recent studies have not found fish from this ESU in the region and they are considered unlikely to occur in the ROI.

Invertebrates. As with fish, the wide variety of marine habitats in the ROI support a great diversity and abundance of marine invertebrates. PMSR includes benthic habitats at a variety of depths with a diversity of substrate types (described in the introduction to **Section 3.3.14.2** and in U.S. Navy 2002). Benthic habitats on the nearshore continental shelf support several clam species including pismo (*Tivela stultorum*), *Tellina*, *Macoma*, and *Spisula* clams in shallow waters; geoduck (*Panopea generosa*) in mid-depth waters; and *Cardita ventricosa* in deeper shelf waters (U.S. Navy 2002). Other shallow water invertebrates include sand dollars (Order Clypeasteroidea) and tube-dwelling polychaete worms of the genera *Diopatra*, *Nothria*, *Onuphis*, *Owenia*, and *Pista* (U.S. Navy 2002). In deeper shelf waters, there are invertebrates such as burrowing echiuroid worms (*Listriolobus pelodes*), sea cucumbers, several species of small deposit-feeding bivalves, and other varieties of tube-dwelling polychaete worms (U.S. Navy 2002). In addition, numerous predatory and opportunistic invertebrates (i.e., scavengers) are common in these deeper water assemblages (e.g., various crabs, hermit crabs, starfish, and snails; U.S. Navy 2002).

Offshore shelves, ridges, and banks provide unique benthic habitats that support the most diverse benthic invertebrate communities in PMSR due to persistent upwelling and diverse sediment types (U.S. Navy 2002). Dominant invertebrates in these habitats extend into waters 500 m [1,640 ft]) deep and include polychaetes (*Chloeia pinnata*, *Lumbrineris* spp.), brittle stars (*Amphipholis squamata*, *Amphiodia urtica*), bivalves (*Parvilucina tenuisculpta*), ostracods (*Euphilomedes* spp.), and amphipods (*Photis californica*; U.S. Navy 2002).

Invertebrate diversity and abundance is generally lower in slope habitats and decreases with depth (U.S. Navy 2002). Upper slopes (waters 150 to 500 m [492 to 1,640 ft] deep) have higher invertebrate abundance and diversity than lower slopes with polychaetes (*Chloeia pinnata*, *Pectinaria californiensis*, *Paraprinospio pinnata*, *Maldane sarsi*, *Lumbrineris* spp., *Tharyx* spp.), bivalves (*Cyclocardia ventricosa*), ostracods (*Euphilomedes* spp.), small snails (*Mitrella permodesta*), and spoon worms (*Arhynchite californicus*) dominating assemblages there (U.S. Navy 2002).

The basins, submarine canyons, and abyssal regions of PMSR with water depths from 2,400 to more than 4,000 m (7,900 to 13,100 ft), have very low invertebrate abundance and diversity (U.S. Navy 2002). Some polychaete worms, brittle stars, and *Aplacophora* mollusks (U.S. Navy 2002).

Commercial invertebrate fisheries are also important in the ROI, and the California Department of Fish and Wildlife reports commercial landing in California waters each year. In the report for 2017 (CDFW 2018) the largest crustacean catches (by weight) in the Santa Barbara area were of red (*Cancer productus*), brown (*C. antennarius*), and yellow (*C. anthonyi*) rock crabs; ridgeback (*Sicyonia ingentis*) and spot (*Pandalus platyceros*) prawns; and California spiny lobster (*Panulirus* *interruptus*; CDFW 2018). The largest mollusk landings (by weight) were of various market squid, Kellet's welk (*Kelletia kelleii*), and moon snails (*Neverita lewisii*; CDFW 2018). Echinoderms caught in Santa Barbara fisheries included red sea urchins (*Mesocentrotus franciscanus*), bat stars (*Patiria miniata*), warty sea cucumbers (*Parastichopus parvimensis*), and giant red sea cucumbers (*P. californicus*; CDFW 2018).

Corals in the temperate waters off southern California are not reef-building but are an important component of the marine ecosystem and provide habitat that supports many organisms (U.S. Navy 2018). Colonies of Christmas tree black coral (*Antipathes dendrochristos*) off southern California have been known to be colonized by over 2,500 individual invertebrates, including other cnidarians (sea anemones and corals), crustaceans, echinoderms, mollusks, and polychaete worms (U.S. Navy 2018). Surveys conducted on outer continental shelf bank and rock outcrops off southern California have documented numerous coral species, including stony corals (Order Scleractinia), black corals (Order Antipatharia), sea fans (Order Alcyonacea), soft corals (Order Alcyonacea), sea pens (Order Pennatulacea), and hydrocorals (Order Stylasterina or Anthoathecata; U.S. Navy 2018). Deep-water anthozoan and hydrozoan corals have been documented throughout the Southern California Bight as well (U.S. Navy 2018). Deep-water areas off the California coast, including the Channel Islands National Marine Sanctuary, support numerous corals such as sea fans (gorgonians), black corals, and stony corals such as the cup coral *Caryophyllia arnoldi* and *Lophelia pertusa* (U.S. Navy 2018).

The only ESA-listed invertebrates known to occur in PMSR are the white abalone (*Haliotis sorenseni*) and the black abalone (*H. cracherodii*). The ESA-endangered white abalone are typically found in subtidal waters 5 to 60 m (16 to 197 ft) deep and are currently most abundant at depths of 40 to 50 m (130 to 160 ft; NMFS 2018). This sessile benthic species prefers reefs and rock piles surrounded by sandy areas (U.S. Navy 2018). White abalone are known to occur on offshore banks, off mainland southern California, and around several of the Channel Islands (NMFS 2018). Black abalone are also listed as endangered under the ESA. This species occurs in the intertidal zone, generally on rocky substrates in the middle and lower intertidal zone (U.S. Navy 2018). Black abalone are known to occur around several Channel Islands including San Miguel and Santa Cruz within Channel Islands National Park. Abalone populations have declined dramatically in the last 40 years, and NMFS has identified overharvesting, low population density, loss of genetic diversity, disease, poaching, and natural predation as the primary factors contributing to decline of abalone species (NMFS 2018). Critical habitat for the black abalone has been designated (**Figure 3-1**) and is discussed in the "Environmentally Sensitive Habitats" subsection below.

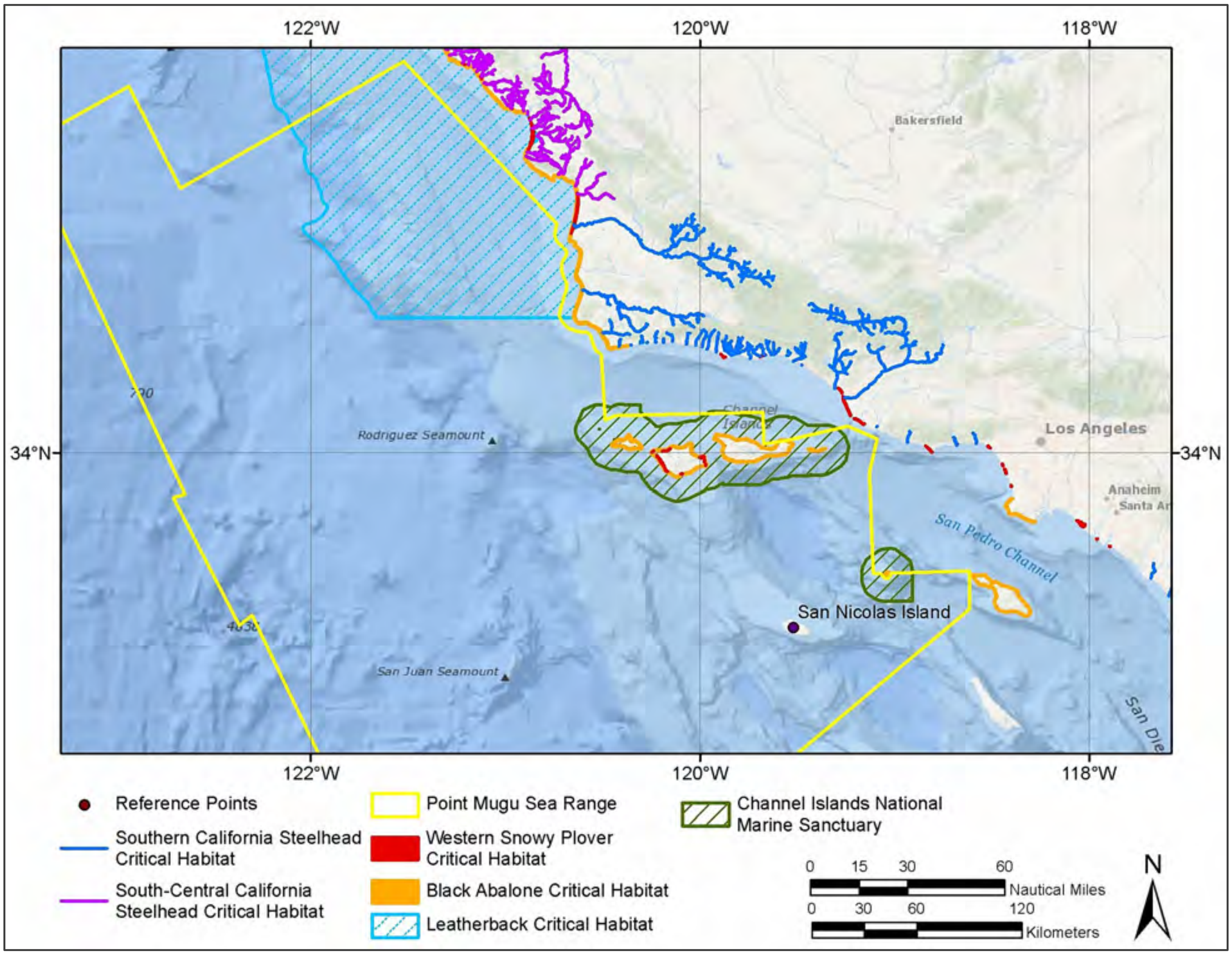

Figure 3-1. Designated Critical Habitat and Protected Areas Near Point Mugu Sea Range.

Environmentally Sensitive Habitats and Protected Areas

Environmentally sensitive habitats are those areas designated by the USFWS or NMFS as critical habitat for ESA listed species or other sensitive habitats such as wetlands, habitats limited in distribution, or important seasonal use areas for wildlife (e.g., breeding areas, feeding areas, or migration routes). Designated critical habitats and protected areas in the vicinity of PMSR (**Figure 3-1**) are discussed in this section.

Black Abalone Critical Habitat. Critical habitat was designated under the ESA for the black abalone in 2011 (76 FR 66806 [27 October 2011]). Critical habitat includes approximately 360 km^2 (139 mi^2) of rocky intertidal and subtidal marine habitats from the mean higher high-water line to a depth of 6 m (20 ft) along the California coast as well as several islands (**Figure 3-1**). Primary constituent elements essential for the conservations of black abalone include rocky substrate, food resources (bacterial and diatom films, coralline algae, and a source of detrital macroalgae), juvenile settlement habitat, (rocky intertidal and subtidal habitat), suitable water quality, and suitable nearshore circulation (76 FR 66806 [27 October 2011]).

Leatherback Critical Habitat. The NMFS designated critical habitat for leatherback sea turtles along the U.S. West Coast in 2012 (77 FR 4170 [26 January 2012]). The designation covers approximately 43,798 km^2 (16,910 mi^2) of waters along the California coast and includes waters from the surface down to a maximum of 80 m (262 ft) from the shoreline out to the 3,000 m (9,840 ft) depth contour (77 FR 4170 [26 January 2012]). The primary constituent element essential for conservation of leatherback sea turtles identified in the final rule is "the occurrence of prey species, primarily scyphomedusae of the order Semaeostomeae (e.g., *Chrysaora, Aurelia, Phacellophora*, and *Cyanea*), of sufficient condition, distribution, diversity, abundance and density necessary to support individual as well as population growth, reproduction, and development of leatherbacks" (77 FR 4170 [26 January 2012]).

Western Snowy Plover Critical Habitat. The USFWS designated critical habitat for the Pacific Coast DPS of the Western snowy plover (*Charadrius nivosus nivosus*) in 1999 and 2005 then revised the designation in 2012 (77 FR 36727 [19 June 2012]). This critical habitat includes 9,926 ha (24,527 acres) of coastal terrestrial habitat with the essential physical and biological features for conservation of Western snowy plovers (77 FR 36727 [19 June 2012]). Primary constituent elements in this critical habitat include sandy beaches, dune systems immediately inland of an active beach face, salt flats, mud flats, seasonally exposed gravel bars, artificial salt ponds and adjoining levees, and dredge spoil sites, that are below heavily vegetated or developed areas, above high tide, with areas for feeding, and minimal disturbance (77 FR 36727 [19 June 2012]).

California Coastal National Monument. Established in 2000 and expanded in 2014, the California Coastal National Monument protects offshore islands, rocks, exposed reefs, and pinnacles owned or controlled by the U.S. Government within 22 km (12 nm) of the California Shoreline (U.S. Navy 2002, 3 CFR 9089 [11 March 2014]). The California Coastal National Monument comprises approximately 405 ha (1,000 acres) of offshore rocks and islands as well as 3,207 ha (7,924 acres) onshore (BLM 2019). The monument included the feeding and nesting habitat for an estimated 200,000 breeding seabirds as well as foraging and breeding habitat for California sea lions, harbor seals, elephant seals, and southern sea otters (3 CFR 9089 [11 March 2014]).

The Channel Islands National Marine Sanctuary (CINMS) & The Channel Islands National Park (CINP). The CINMS encompasses the waters within 11 km (6 nm) of San Miguel, Santa Rosa, Santa Cruz, Anacapa, and Santa Barbara islands. The CINP boundaries extend 1.9 km (1 nm) beyond the coast of each of these islands. The CINMS was established in 1980 for the purpose of protecting areas off the southern California coast which contain significant marine resources. The CINMS is located over the continental shelf, with water depths generally less than 110 m (360 ft). Waters surrounding the Channel Islands are relatively undisturbed and provide a habitat for a diverse assemblage of marine organisms. (U.S. Navy 2002)

Essential Fish Habitat (EFH). EFH and its geographic boundaries in and near PMSR have been designated by the Pacific Fisheries Management Council (PFMC) under the MSA. The PFMC has developed EFH and habitat areas of particular concern (HAPC) designations for Pacific coast groundfish, coastal Pelagic species, and highly migratory species. Complete descriptions of the designated EFH and HAPCs for each life history stage for each managed species are included in the Fishery Management Plans for each group; Coastal pelagic species (PFMC 1998), Pacific coast groundfish (PFMC 2016), and highly migratory species (PFMC 2018). The designated EFH and HAPC in the PMSR portion of the ROI are summarized in **Table 3-3** and shown in **Figure 3-2** and **Figure 3-3**.

Table 3-3. Designated Essential Fish Habitat (EFH) and Habitat Areas of Particular Concern (HAPC) in and Near PMSR.

Management Unit	EFH	HAPC
Coastal Pelagic Species	All marine and estuarine waters above the thermocline from the shoreline offshore to 370 km (200 nm) offshore.	None
Pacific Coast Groundfish	All waters and substrate within the following areas: • Depths less than or equal to 3,500 m (11,500 ft) to mean higher high-water level or the upriver extent of saltwater intrusion. • Seamounts in depths greater than 3,500 m (11,500 ft) as mapped (PFMC 2016). • Areas designated as HAPCs not included above.	Estuaries, canopy kelp, seagrass, rocky reefs, and “areas of interest”, including several seamounts off of California.
Highly Migratory Species	All marine waters from the shoreline offshore to 370 km (200 nm) offshore.[1]	None

Sources: PFMC 1998, PFMC 2016, PFMC 2018, U.S. Navy 2013
[1] Varies by species but encompassed by this definition.

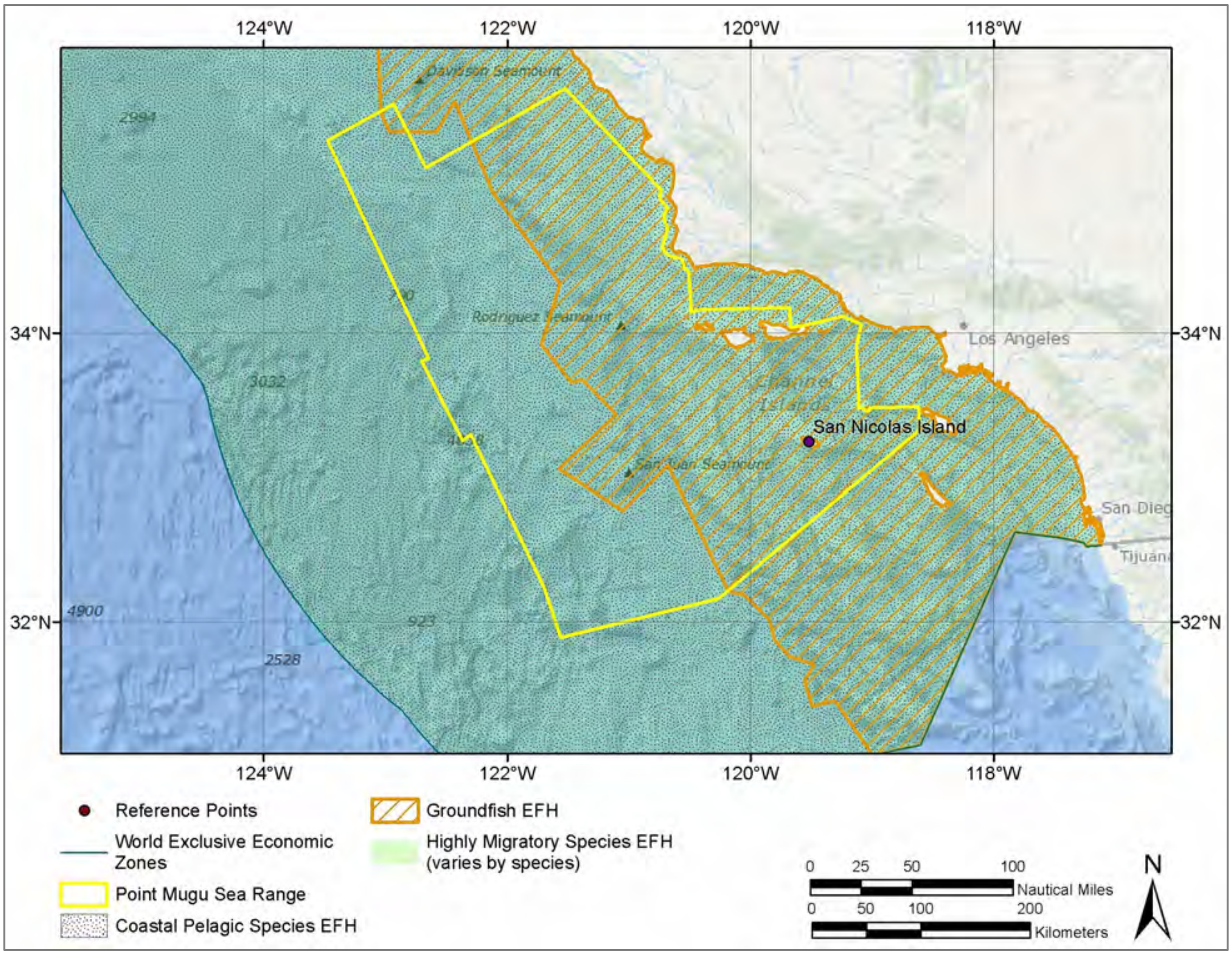

Figure 3-2. Essential Fish Habitat (EFH) in and Near Point Mugu Sea Range.

Coastal pelagic species with designated EFH (**Table 3-3**) include northern anchovy, jack mackerel (*Trachurus symmetricus*), Pacific sardine, Pacific mackerel, and market squid (*Loligo opalescens*; PFMC 1998). These fish are pelagic, generally occurring above the thermocline in the upper mixed layer of water and all are treated as a single species complex (along with the squid) because of similarities in habitat requirements (PFMC 1998).

There are 87 species managed under the Pacific Coast Groundfish Fishery Management Plan (PFMC 2016). These species include with designated EFH (**Table 3-3**) include leopard sharks (*Triakis semifasciata*), longnose sharks (*Raja rhina*), big skates (*R. binoculata*), spiny dogfish (*Squalus suckleyi*), 6 species of roundfish, 65 species of rockfish, and 12 species of flatfish (PFMC 2016). Designated HAPCs for groundfish are shown in **Figure 3-3**.

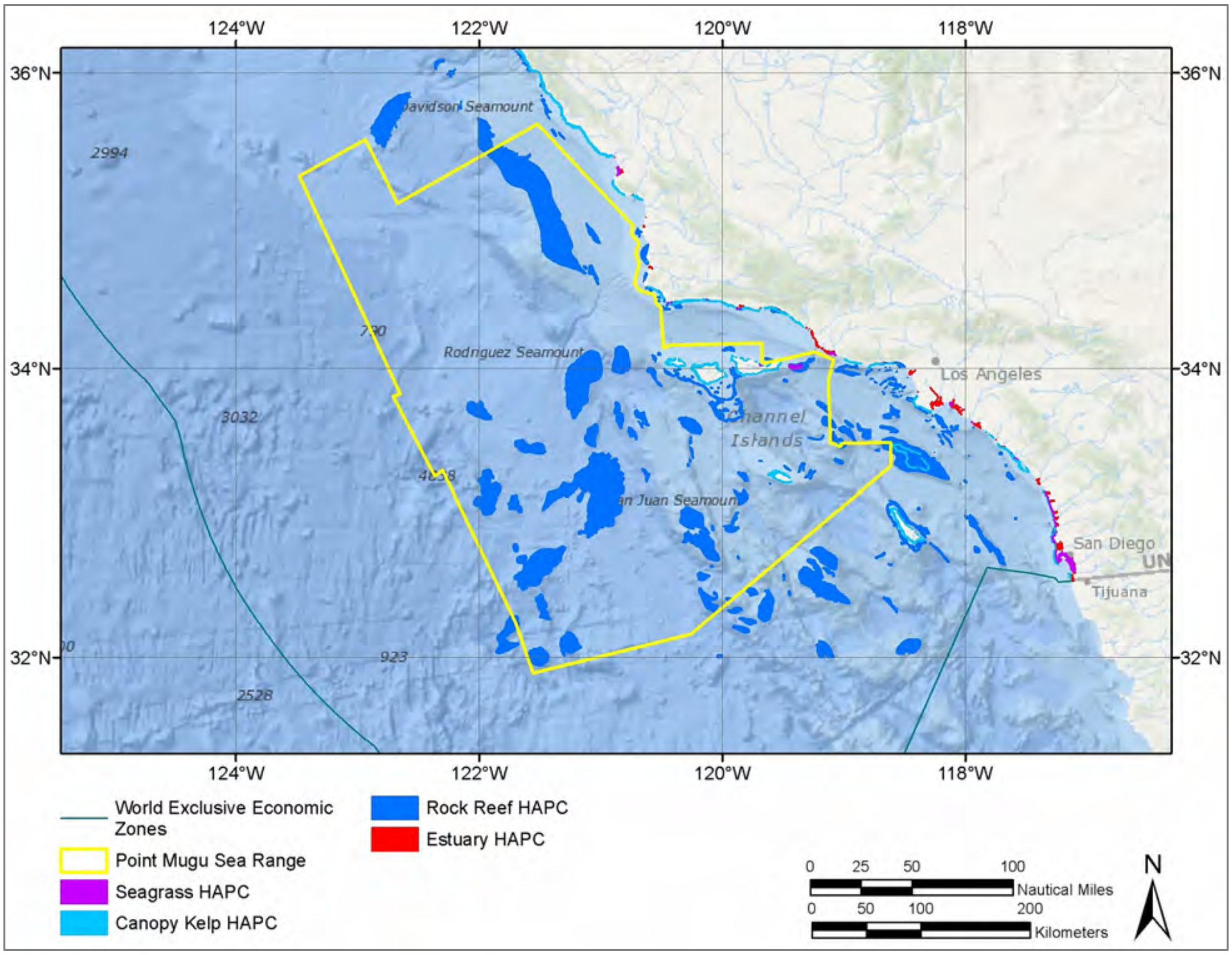

Figure 3-3. Groundfish Habitat Areas of Particular Concern (HAPC) in and Near Point Mugu Sea Range.

Species with designated EFH under the U.S. West Coast Fisheries Management Plan for Highly Migratory Species (PFMC 2018) include common thresher sharks (*Alopias vulpinus*), shortfin mako sharks (*Isurus oxyrinchus*), blue shark (*Prionace glauca*), albacore tuna (*Thunnus alalunga*), bigeye tuna (*T. obesus*), Pacific bluefin tuna (*T. orientalis*), skipjack tuna (*Katsuqonus pelamis*), yellowfin tuna (*T. albacares*), striped marlin (*Kajikia audax*), swordfish, and dolphinfish (*Coryphaena hippurus*; PFMC 2018). EFH for these species varies by species and life history stage as detailed in PFMC 2018 but overall includes all marine waters from the shoreline offshore to the EEZ boundary.

3.4 Broad Ocean Area

This section includes assessment of air quality and biological resources within the BOA, for the ARRW test series 1 and 2 flights. The potential impacts to all other resource areas are considered to be negligible or non-existent; as such, they are identified but were not analyzed in detail in this EA/OEA. Socioeconomics are not addressed within this section, due to the flight path within the BOA having no direct impact to socioeconomics for any specific region or land mass prior to impact location.

For the purposes of the ARRW test series 1 and 2 flight tests, the boundaries of the BOA are defined as beginning at the point of aerial drop and initial solid rocket motor ignition, terminating within the BOA (**Figure 1-2**). Evaluation of resource areas is limited to the BOA. Additionally, for the purposes of the ARRW test series 2 flight tests, the boundaries of the BOA are defined as beginning at the point of aerial drop and initial solid rocket motor ignition, terminating with impact at Illeginni Islet. Evaluation of resource areas is limited to these boundaries, only.

Potential impacts to resources from ground operations and aircraft departure point at Edwards AFB, California, to aerial drop are addressed in the *Environmental Assessment for Increasing Routine Flight Activities, Edwards Air Force Base. California* (AFFTC 2009) and the *Environmental Assessment for the Continued Use of Restricted Area R-2515, Edwards AFB* (AFFTC 1998). Potential impacts to resources from ground operations and aircraft departure point at Barksdale AFB, Louisiana are addressed in the *Environmental Assessment Addressing Construction and Operation of a Weapons Storage and Maintenance Facility, Barksdale Air Force Base, Louisiana* (USAF 2017). This EA/OEA does not assess potential impacts during the transit of the weapons system from aircraft departure point to aerial release point.

3.4.1 Water Resources

There are no groundwater or surface water resources within the BOA that would be affected by the ARRW test series 1 or 2 flight tests. There would be no disturbance to ocean waters beyond the spent component (with inert payload as applicable) and shroud splashing into the ocean along the flight path, sinking thousands of meters (feet). There is a low probability that the spent component could float on the ocean surface post-splashdown. As discussed in **Section 2.4.6.1**, any floating debris would be recovered and appropriately disposed of. No impacts would occur to water resources within the over-ocean flight corridor from the ARRW test series 1 or 2 flight tests.

3.4.2 Geological Resources

There would be no drilling, mining, or construction in the open ocean and no marine sediment disturbance beyond the settling of the spent component and shroud as they come to rest on the sea floor. There would be no impacts to geological resources in the BOA from the ARRW test series 1 or 2 flight tests.

3.4.3 Cultural Resources

There are no identified cultural resources within the BOA; therefore, there would be no impacts to cultural resources from the ARRW test series 2 flight tests.

3.4.4 Land Use

The ARRW test series 1 and 2 flight paths would avoid populated land masses. There would be no changes, and therefore, no impacts, from the ARRW test series 1 or 2 flight tests to land use within the BOA.

3.4.5 Airspace

The flight corridor is located over international airspace and, therefore, has no formal airspace restrictions governing it. Over-ocean flight tests must comply with DOD Instruction 4540.01, Use of International Airspace by U.S. Military Aircraft and for Missile/Projectile Firings. Commercial and private aircraft would be notified through NOTAMs issued through the FAA in advance of the ARRW test series 1 and 2 flight tests at the request of RTS as part of their routine operations. ARRW test series 1 and 2 test flight operations would be conducted in accordance with Western Range procedures and would not expand or alter currently controlled airspace. There would be no impacts to airspace within the BOA from the ARRW test series 1 and 2 flight tests.

3.4.6 Noise

The ARRW test series 1 and 2 flight tests would occur at an altitude where they would be generally undetected by vessels or aircraft at the ocean's surface. Sonic booms are generated following solid rocket motor ignition and during terminal flight and impact. Only the sonic boom created by the solid rocket motor ignition would occur over the BOA. Therefore, there would be no impacts to noise within the BOA.

3.4.7 Infrastructure

No changes would occur to infrastructure from either the ARRW test series 1 or 2 flight tests; therefore, there would be no impacts to infrastructure in the BOA.

3.4.8 Transportation

Transportation services would be unaffected by the ARRW test series 1 and 2 flight tests over the open ocean. The ARRW test series 1 and 2 flights would occur at high altitude where they would be generally undetected by vessels or aircraft. Public NOTAMs and NTMs would be issued along the flight path, between the drop and ignition point and impact point, to ensure the safety of both aircraft and vessels. Components would drop to the ocean surface within the predetermined BOA. Through issuance of the NOTAMs and NTMs, there should be no vessels or aircraft in the vicinity.

Therefore, there would be no impacts from the ARRW test series 1 or 2 to transportation along the flight path over the open ocean.

3.4.9 Public Health and Safety

The ARRW test series 1 and 2 flights would occur at high altitudes where they would be generally undetected by vessels or aircraft. NOTAMs and NTMs would be issued along the flight path to ensure the safety of personnel on aircraft and vessels. Components would drop over predetermined open ocean areas to ensure, along with the public notices, that there would be no vessels or aircraft in the vicinities. If the ARRW vehicle (series 1 or series 2) were to deviate from its course or should other problems occur during flight that might jeopardize public safety, the onboard FTS would be activated. This action would initiate a destruct charge causing the ARRW vehicle to fall towards the ocean and terminate flight. The FTS would be designed to prevent any debris from falling into any protected area. No inhabited land areas would be subject to unacceptable risks of falling debris. There would be no impacts from the ARRW test series 1 or 2 flight tests to public health and safety along the flight path over the over-ocean flight corridor.

3.4.10 Hazardous Materials and Wastes

The ARRW test series 2 would exhaust on-board propellant prior to separation and before the spent motor drops into the ocean. *De minimus* residual quantities of materials may remain on the ARRW test series 2 vehicle and shroud and would be carried to the ocean floor by the sinking components. There is a low probability that the spent component could float on the ocean surface post-splashdown. Floating debris is considered unlikely; however, there is a low probability that the spent component could float on the ocean surface post-splashdown. As discussed in **Section 2.4.6.1**, any floating debris would be recovered and appropriately disposed of. The ARRW test series 2 payload would proceed over the BOA to impact at Illeginni Islet.

Table 2-1 describes the ARRW test series 1 and 2 mechanical and chemical characteristics. After aerial drop, the $BKNO_3$ pyrogen igniter and solid propellant would be burned as part of the start of the ARRW propulsion system. Approximately 1,633 kg (3,600 lb) of aluminized HTPB would then be burned as propellent during flight. The ARRW test series 1 test propulsion system would commence over PMSR and continue in a westward trajectory, with the ARRW test series 1 vehicle impacting into the BOA. The ARRW test series 2 propulsion system would commence over the BOA and continue in a westward trajectory over the BOA until the spent components splash down in the BOA, and the terminal impact of the payload at Illeginni Islet. The ARRW would have two onboard battery powered systems (28-volt and 150-volt batteries), both adhering to Military Standard 1760 power source requirements. Considering the small quantities of hazardous materials contained in the batteries and the dilution and mixing capabilities of the ocean waters and atmosphere, the battery materials that may be potentially released should be of little consequence to any receptors. Because the Proposed Action would be performed at high altitude, the affected environment is relegated to air quality, global atmosphere, and climate change. A discussion of the effect of the igniter and propellent in the atmosphere can be found in **Section 4.2.13**. There would be no impacts from hazardous materials and wastes along the over-ocean flight corridor (BOA) from the ARRW test series 1 or 2 flight tests.

3.4.10.1 Regulatory Setting

Hazardous materials are defined by the U.S. Department of Transportation as a substance or material that is capable of posing an unreasonable risk to health, safety, or property when transported in commerce and has been so designated.

Hazardous wastes are controlled by RCRA (42 USC § 6901 et seq.); however, the ARRW test series 1 test propulsion system would commence over PMSR and continue in a westward trajectory over the BOA, then would impact in the BOA. The ARRW test series 2 propulsion system would commence over the BOA with the spent components impacting in the BOA, and the test series 2 payload impact at Illeginni Islet. The ARRW test series 1 tests and ARRW test series 2 flight tests would result in trace (*de minimis*) amounts of hazardous waste as a result of the Proposed Action. RCRA 42 USC § 6924 (section (q)) allows for an exemption of hazardous waste used as fuel if the waste is destroyed and removed sufficiently such that protection of human health and environment is assured. The latter describes the Proposed Action.

3.4.11 Environmental Justice

Range safety regulations and procedures protective of health and safety would be applied during flight test operations. There would be no disproportionate impacts within the over-ocean flight corridor to minority populations or low-income populations under EO 12898 from the ARRW test series 1 or 2 flight tests.

3.4.12 Visual Resources

The ARRW test series 1 and 2 flights would occur at high altitude where it would be generally undetected by vessels or aircraft. There would be no impacts to visual resources from either the ARRW test series 1 or 2 (flight path).

3.4.13 Air Quality, Greenhouse Gases and Climate Change

3.4.13.1 Regulatory Setting

Because of the potential global effects of testing rockets over the ocean and through the Earth's atmosphere, this EA/OEA considers the environmental effects on the global environment in accordance with the requirements of EO 12114, *Environmental Effects of Major Federal Actions*; Department of Defense Directive (DODD) 6050.7, *Environmental Effects Abroad of Major Department of Defense Actions; and* EO 13834, *Efficient Federal Operations*, which outlines policies to ensure that federal agencies evaluate and improve their energy efficiency. This section describes the baseline conditions within the BOA (**Figure 1-2**) that may be affected by the ARRW test series 1 and 2 flight tests.

3.4.13.2 Air Quality

The stratosphere, which extends from 10 km (6 mi) to approximately 50 km (30 mi) in altitude, contains the Earth's ozone layer (NOAA 2008). The ozone layer plays a vital role in absorbing harmful ultraviolet radiation from the sun. Over the last 20 years, anthropogenic (human-made) gases released into the atmosphere—primarily chlorine related substances—have threatened ozone concentrations in the stratosphere which filter harmful ultraviolet sunlight. Such materials include CFCs, which have been widely used in electronics and refrigeration systems, and the lesser-used halons, which are extremely effective fire extinguishing agents. Once released, the motions of the atmosphere mix the gases worldwide until they reach the stratosphere, where ultraviolet radiation releases their chlorine and bromine components.

Through global compliance with the 1987 Montreal Protocol on Substances that Deplete the Ozone Layer and amendments, the worldwide production of CFCs and other ozone-depleting substances has been drastically reduced and banned in many countries. A continuation of these compliance efforts is expected to allow for a slow recovery of the ozone layer (World Meteorological Organization 2016).

Atomic chlorine produced from emissions of hydrogen chloride during high-temperature afterburning reactions in the exhaust plume of solid propellant rocket motors can contribute to overall global chlorine loading, which contributes to long-term ozone depletion. Stratospheric hydrogen chloride is diffused through the troposphere and dissipates with a half-life of about 2.3 years; however, hydrogen chloride from rocket emissions could have longer lifetimes because part of the emission occurs at atmospheric levels above the stratosphere. Studies have shown that aluminum oxide, which is emitted from the rocket exhaust as solid particles, could contribute to ozone depletion via activation of chlorine in the atmosphere. Emissions of nitrogen oxides produced in the exhaust plume of rockets can also contribute to stratospheric ozone depletion.

Impacts of the ARRW test series 1 and 2 flight tests on global warming and ozone depletion in the atmosphere have also been considered as part of cumulative impacts in **Chapter 5.0**.

3.4.13.3 Greenhouse Gases

The CEQ final guidance (CEQ 2016) recommended that agencies use projected GHG emissions as a proxy for assessing potential climate change effects or include a qualitative analysis when quantification is not reasonably available when preparing NEPA documents. The guidance is primarily focused on projects that have large air quality implications and emphasizes a netting approach to GHG analysis. Although not specifically identified in the final 2016 guidance, the prior draft guidance included a reference point of 25,000 metric tons per year (27,558 tons per year) of carbon dioxide equivalent emissions for discussion and disclosure of such emissions from larger federal actions that may have appreciable GHG emissions (CEQ 2014). This threshold was carried forward to determine if additional quantitative analysis would be required for the ARRW test series 1 and 2 flight tests within this EA/OEA.

3.4.13.4 Climate Change

Current global climate changes are scientifically attributable to global warming occurring from GHG emissions. The global annual temperature has increased at an average rate of 0.07°C (0.13°F) per decade since 1880 and at an average rate of 0.17°C (0.31°F) per decade since 1970. The warmest global average temperatures on record have all occurred within the past 15 years, with the warmest years being 2010, 2013, 2014, and 2015 (NOAA 2016). With this in mind, the USAF, through DoD directive, is poised to support climate-changing initiatives globally, while preserving military operations, sustainability, and readiness by working, where possible, to reduce GHG emissions.

Sea level rise from global warming is primarily ascribed to water flowing into the sea from melting freshwater ice on land and the expansion of sea water as it warms. Tracked by satellites (1993–2016) and as measured along coast lines (1870–2000), according to NASA (Nerem et al. 2018) the current rate of sea level rise is 3.41 millimeters (0.13 in.) per year.

3.4.13.5 Region of Influence – Over-Ocean Flight Corridor

Dominant during much of the year, trade winds effectively disperse air emissions along the over-ocean flight corridor. Studies in Pacific locations have shown seasonal variations in the concentrations of man-made emissions, consisting of sulfate, nitrate, and dust. Each spring, large quantities of pollution, aerosols, and mineral dust are carried eastward out of Asia and transported over a broad region of the northern Pacific Ocean. Although an increasing trend in emission levels was occurring from the early 1980s to the mid-1990s, a more recent downward trend was recorded through 2000. Because of the lack of local air pollution sources, the dispersal of emissions by trade winds, and the lack of topographic features that inhibit dispersion, air quality along the BOA over-ocean flight corridor is considered good. Unlike the Continental United States, tropospheric ozone is not a concern in this general area.

Changes in sea level have occurred throughout history, with the primary influences being global temperatures; Arctic, Antarctic, and glacial ice masses; and changes in the shape of the oceanic basins and land/sea distribution. Generally, with rising global temperatures, less ice is created or maintained throughout the Earth and sea levels rise. Currently, small islands located within the over-ocean flight corridor may be affected by rising sea levels from global climate change.

3.4.14 Biological Resources

Biological resources described in this section are those within the affected environment of the over-ocean flight corridor in the BOA, specifically those areas subject to ARRW test series 1 and 2 flight tests and splashdown of vehicle components (**Figure 1-2**). Special status species including those protected under the ESA and MMPA have been described in detail, and environmental consequences of ARRW test series 2 flight tests have been analyzed in the USAF ARRW BA (USAF and USASMDC 2019).

3.4.14.1 Regulatory Setting

For the purposes of this EA/OEA, special status species in the BOA are those species listed as threatened or endangered under the ESA, species protected under the MMPA, and species protected under the MBTA. The ESA, MMPA, and MBTA are described in **Section 3.3.14.1** including definitions. The effects on biological resources are evaluated in accordance with the requirements of EO 12114, *Environmental Effects of Major Federal Actions* and DOD procedures for implementing EO 12114 (32 CFR § 187).

3.4.14.2 Biological Resources in the Pacific Ocean Flight Corridor Region of Influence

The potential region of influence (ROI) is in the BOA of the Pacific Ocean from approximately 2° to 44°N and from 121° to 160°W (**Figure 1-2**). For the purposes of this document, the BOA is defined as an expanse of open ocean area of the Pacific encompassed by the extent shown in **Figure 1-2**. The BOA includes only waters outside of the EEZs of the United States and other countries with territory in the central Pacific. The waters of the BOA consist of deep ocean waters with both pelagic and benthic habitats. Pelagic areas support communities of planktonic (drifting) and nektonic (swimming) organisms. Benthic communities vary with water depth and are made up of marine organisms that live on or near the sea floor such as bottom dwelling fish, mollusks, crustaceans, and echinoderms. **Table 3-4** lists all special status species with the potential to occur in the BOA. Threatened, endangered, and other special status species are discussed in their respective categories. No designated critical habitat for any special status species occurs in the BOA. There are no terrestrial habitats in the BOA; however, some seabirds that breed on land and forage in open ocean areas of the Pacific have the potential to occur in the ROI.

Table 3-4. Special Status Species known to Occur or Potentially Occur in the BOA ROI.

Common Name	Scientific Name	Federal Listing Status	Likelihood of Occurrence in Pacific BOA
Cetaceans			
Minke whale	*Balaenoptera acutorostrata*	MMPA	L
Sei whale	*B. borealis*	E, MMPA-Depleted	L
Bryde's whale	*B. edeni*	MMPA	L
Blue whale	*B. musculus*	E, MMPA-Depleted	L
Fin whale	*B. physalus*	E, MMPA-Depleted	L
Short-beaked common dolphin	*Delphinus delphis*	MMPA	L
Pygmy killer whale	*Feresa attenuata*	MMPA	P
Short-finned pilot whale	*Globicephala macrorhynchus*	MMPA	L
Risso's dolphin	*Grampus griseus*	MMPA	L
Longman's beaked whale	*Indopacetus pacificus*	MMPA	P
Pygmy sperm whale	*Kogia breviceps*	MMPA	L
Dwarf sperm whale	*K. sima*	MMPA	L
Fraser's dolphin	*Lagenodelphis hosei*	MMPA	L
Northern right whale dolphin	*Lissodelphis borealis*	MMPA	P
Humpback whale	*Megaptera novaeangliae*	E[1], MMPA-Depleted	L
Hubbs' beaked whale	*Mesoplodon carlhubbsi*	MMPA	P
Blainville's beaked whale	*M. densirostris*	MMPA	L
Ginkgo-toothed beaked whale	*M. ginkgodens*	MMPA	P
Killer whale	*Orcinus orca*	MMPA-Depleted	L
Melon-headed whale	*Peponocephala electra*	MMPA	L
Dall's porpoise	*Phocoenoides dalli*	MMPA	P
Sperm whale	*Physeter macrocephalus*	E, MMPA-Depleted	L
False killer whale	*Pseudorca crassidens*	MMPA-Depleted[2]	L
Pantropical spotted dolphin	*Stenella attenuata*	MMPA-Depleted	L
Striped dolphin	*S. coeruleoalba*	MMPA	L
Spinner dolphin	*S. longirostris*	MMPA-Depleted	L
Rough-toothed dolphin	*Steno bredanensis*	MMPA	L
Bottlenose dolphin	*Tursiops truncatus*	MMPA-Depleted	L
Cuvier's beaked whale	*Ziphius cavirostris*	MMPA	L
Pinnipeds			
Guadalupe fur seal	*Arctocephalus townsendi*	T, MMPA-Depleted	P
Northern fur seal	*Callorhinus ursinus*	MMPA-Depleted	P
Northern elephant seal	*Mirounga angustirostris*	MMPA	P
Hawaiian monk seal	*Neomonachus schauinslandi*	E, MMPA-Depleted	U

Common Name	Scientific Name	Federal Listing Status	Likelihood of Occurrence in Pacific BOA
Birds			
Band-rumped storm petrel	*Oceanodroma castro*	E, MBTA	P
Hawaiian petrel	*Pterodroma sandwichensis*	E, MBTA	L
Short-tailed albatross	*Phoebastria albatrus*	E, MBTA	U
Newell's shearwater	*Puffinus auricularis newelli*	T, MBTA	L
Sea Turtles			
Loggerhead turtle	*Caretta caretta*	E[3]	L
Green turtle	*Chelonia mydas*	E, T[4]	L
Leatherback turtle	*Dermochelys coriacea*	E	L
Hawksbill turtle	*Enetmochelys imbricata*	E	L
Olive ridley turtle	*Lepidochelys olivacea*	T[5]	L
Fish			
Bigeye thresher shark	*Alopias superciliosus*	-	L
Oceanic whitetip shark	*Carcharhinus longimanus*	T	L
Oceanic giant manta ray	*Manta birostris*	T	P
Pacific bluefin tuna	*Thunnus orientalis*	-	P

Abbreviations: BOA = Broad Ocean Area; ESA = Endangered Species Act; MMPA = Marine Mammal Protection Act; MBTA = Migratory Bird Treaty Act; E = federal endangered; T = federal threatened; L = Likely; P = Potential; U = Unlikely.
[1] The Hawai'i distinct population segment (DPS) is not listed under the ESA. The eastern north Pacific DPS is listed as endangered. There is some evidence that eastern north Pacific DPS whales may transit the ROI.
[2] The DPS of false killer whales likely in the ROI are not listed under the ESA; however, the Hawaiian Insular DPS is listed as endangered under the ESA.
[3] North Pacific Ocean DPS.
[4] The green turtle is currently listed based on DPSs. Green turtles in the ROI may belong to two DPSs; the central west Pacific DPS includes turtles in the Marshall Islands and is listed as endangered while turtles around Hawaii are in the central North Pacific DPS and are listed as threatened (Seminoff et al. 2015, NOAA 2018a).
[5] As a species, the olive ridley turtle is listed as threatened, but the Mexican Pacific Coast nesting population is listed as endangered. Some olive ridley turtles in the ROI may be from this east Pacific Coast nesting population (NMFS and USFWS 2007a, NMFS and USFWS 2014).

3.4.14.3 Marine Wildlife in the Pacific Ocean Flight Corridor

Marine wildlife in the BOA that are considered in this EA/OEA are those that have the potential to be in the ARRW test series 1 and 2 over ocean flight corridor and may be exposed to elevated noise levels from the ARRW vehicle flights, splashdown of ARRW series 1 components, hazardous chemicals, or vessel activity.

Marine Mammals. Several species of cetaceans and pinnipeds have been documented in the BOA. All marine mammal species in the ROI are protected under the MMPA, and seven species are listed under the ESA. In addition to the seven ESA listed species, which are all considered to have depleted stocks under the MMPA, four other cetacean species also have depleted stocks. All of these species have been described in detail and environmental consequences of the ARRW program have been analyzed in the USAF ARRW BA (USAF and USASMDC 2019). Given the large extent of the BOA, there are 23 cetacean species likely to occur in some portion of the BOA. Six other cetacean species are considered to have the potential to occur in the ROI as they have limited range overlap with the BOA. If present, these species would likely have very low densities in the BOA for most of the year. Some of these species such as humpback whales, short-finned pilot whales (*Globicephala macrorhynchus*), killer whales, spinner dolphins (*Stenella longirostris*), and bottlenose dolphins, have more coastal distributions. These species are more likely to occur in coastal waters which mostly occur within EEZs. However, these species transit deeper offshore waters and may occur in higher numbers in the BOA seasonally. Cetacean species with the highest maximum density estimates in the BOA include short-beaked common dolphins, northern right whale dolphins, and striped dolphins (*Stenella coeruleoalba*) (USAF and USASMDC 2019).

Four pinnipeds have the potential to occur in the BOA: the Guadalupe fur seal, northern fur seal, northern elephant seal, and Hawaiian monk seal (*Neomonachus schauinslandi*; **Table 3-4**). The Guadalupe fur seal only occurs in the eastern portion of the BOA. This species primarily forages within the U.S. and Mexico EEZs (Marine Mammal Center 2018); however, these fur seals are known to forage up to 589 km (240 nm) from land (Gallo-Reynoso et al. 2008) and have the potential to occur in the BOA. Northern fur seals and elephant seals are both species that forage at sea and their ranges overlap a small portion of the BOA (NOAA 2018a). While these species have the potential to occur in northern and eastern areas of the BOA, their occurrence in the BOA varies seasonally and they likely have low densities in this area. Hawaiian monk seals breed only on the Hawaiian Islands, with the majority of breeding and pupping taking place on the Northwest Hawaiian Islands (NMFS 2011). Monk seals are known to forage in offshore areas up to 700 km (378 nm) from the Hawaiian Islands and in waters up to 500 m (1,640 ft) deep (NMFS 2011). However, monk seals spend the majority of their time close to shore in waters less than 90 m (300 ft) deep and within the Hawaiian Islands EEZ (NMFS 2011) and are therefore unlikely to occur in the BOA.

Potential threats to marine mammals in the Pacific BOA include ingestion of marine debris, entanglement in fishing nets or other marine debris, collision with vessels, loss of prey species due to new seasonal shifts in prey species or overfishing, excessive noise above baseline levels in a given area, chemical and physical pollution of the marine environment, parasites and diseases, and changing sea surface temperatures due to global climate change (NOAA 2018a).

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

Birds. While no terrestrial habitat occurs in the BOA ROI, many seabirds have wide ranging at-sea foraging distributions and extensive pelagic migrations in the Pacific. It is likely that several seabird species may forage or rest at sea in the BOA. Some seabird species are relatively common in portions of the BOA including sooty tern (*Onychoprion fuscatus*), wedge-tailed shearwaters (*Ardenna pacifica*), Juan Fernandez petrels (*Pterodroma externa*), white-necked petrels (*P. cervicalis*), black-winged petrels (*P. nigripennis*), Leach's storm petrels (*Oceanodroma leucorhoa*), sooty shearwaters (*A. gisea*), black-footed albatross (*Phoebastria nigripes*), Laysan albatross (*P. immutabilis*), and red-footed boobies (*Sula sula*; Gould 1974, Ballance et al. 2002, Spear et al. 1999). Other less common or uncommon species known to occur in portions of the BOA include Bulwer's petrels (*Bulweria bulwerii*), pomarine jaegers (*Stercorarius pomarinus*), white terns (*Gygis alba*), masked boobies (*Sula dactylatra*), and red-tailed tropicbirds (*Phaethon rubricauda*; Gould 1974, Ballance et al. 2002, Spear et al. 1999). All of these seabirds are migratory birds protected under the MBTA. The distribution and abundance of these and other seabirds in the BOA varies seasonally and often with prey availability (Gould 1974, Ballance et al. 2002). Four ESA-listed species have the potential to occur in the ROI: band-rumped storm petrel (*Oceanodroma castro*), Hawaiian petrel (*Pterodroma sandwichensis*), short-tailed albatross (*Phoebastria albatrus*), and Newell's shearwater (*Puffinus auricularis newelli*). These species are protected under the ESA and MBTA. No critical habitat for any bird species occurs in the ROI.

Band-rumped storm petrels have a wide distribution with breeding sites in the Pacific and the Atlantic Oceans (USFWS 2005). At-sea, these birds feed on small fish, squid, and crustaceans that they take from the ocean surface (USFWS 2005, USFWS 2015). Little information is available for the pelagic distribution of band-rumped storm petrels in the Pacific. Birds from the Hawaiian population are regularly observed at-sea off Kauai and Hawaii during the breeding season (USFWS 2005) and are known to occur southeast of the Main Hawaiian Islands within 2,200 km (1,188 nm; Spear et al. 1995). The marine range of Hawaiian band-rumped storm petrels is believed to extend through the Northwestern Hawaiian Islands and tropical Pacific, especially near the Equatorial Counter Current (USFWS 2005). There are no known at-sea densities for band-rumped storm petrel; however, their densities are likely to be low in the ROI and their distributions patchy and seasonal.

Hawaiian petrels breed only in the southeastern Hawaiian Islands where they nest in burrows at high elevations (USFWS 1983). Little is known about their non-breeding range or about their pelagic foraging distribution, although satellite tagged birds have been recorded flying more than 4,800 km (3,000 mi) on a single foraging trip from their breeding colonies (USFWS 2011b). The Hawaiian petrel foraging ranges are believed to extend throughout the east Pacific from the Aleutian Islands to the Equator (Wiley et al. 2012). In a 1995 at-sea study, Hawaiian petrels were observed between 125° and 165°W and from the equator north to at least 30°N (Spear et al. 1995).

Newell's shearwaters breed only in the southeastern Hawaiian Islands where they nest in burrows on steep forested mountain slopes (Pyle and Pyle 2009). Little is known about their winter range or about their pelagic foraging distribution. Newell's shearwaters have been primarily recorded in the tropical Pacific between 9–12°N and 160–120°W (Pyle and Pyle 2009, Spear et al. 1995). However, these birds have been observed and collected at Guam, Saipan, Wake Island, Johnston Atoll, and American Samoa (Pyle and Pyle 2009). While little is known about the abundance and distribution of these birds in the open ocean, it is likely that the distribution and abundance of their pelagic food supply determines the at-sea distribution of these seabirds.

Short-tailed albatross were once the most abundant albatross in the North Pacific with millions of birds (USFWS 2009). The current population of short-tailed albatross is less than 2,000 individuals that breed on two remote islands in Japan between October and June (USFWS 2009). Outside of the breeding season, this species migrates to feeding grounds in waters of the Bering Sea, Aleutian Islands, Gulf of Alaska, and the Hawaiian Islands (USFWS 2000). The short-tailed albatross has been observed feeding in both nearshore and pelagic waters (USFWS 2000). In a study of satellite tagged birds, most locations for foraging birds were nearshore in the Bearing Sea, Aleutian Islands, and Gulf of Alaska; however, some locations were recorded in the open ocean west of California, Oregon, and Washington (USFWS 2014). This species is considered unlikely to occur in the BOA.

Sea Turtles. Five species of sea turtle have the potential to occur in the BOA: green, hawksbill (*Enetmochelys imbricata*), leatherback, loggerhead, and olive ridley; all of which are listed under the ESA (**Table 3-4**). Green and hawksbill turtles are the most abundant species in the central Pacific and therefore are most abundant in the BOA. Much of the sea turtle research in the central Pacific has been conducted on the beaches and nearshore waters of Hawai`i; thus, much of the data documenting the species' potential occurrence in the BOA is limited to that region. All of these species have been described in detail and environmental consequences of the ARRW program have been analyzed in the USAF ARRW BA (USAF and USASMDC 2019).

Each sea turtle species has unique life history characteristics that result in different patterns of distribution and abundance in the Pacific. Green, hawksbill, and loggerhead turtles primarily use coastal habitats as adults or large juveniles; however, these turtles use open ocean habitats as hatchlings and juveniles (Polovina et al. 2000, Dutton et al. 2008, NMFS and USFWS 2013b). Green turtles are likely to occur in the BOA of the ROI. While green turtles spend much of their time resting and foraging in shallow, nearshore waters, individuals are also known to migrate through deeper waters of the Pacific (Hanser et al. 2017), sometimes crossing entire ocean basins (NMFS and USFWS 2007c). Studies also suggest that after hatching, juveniles are pelagic (Dutton et al. 2008). Hawksbill turtle hatchlings and small juveniles also live in the open ocean where water depths are greater than 200 m (656 ft) before settling into nearshore coral reef habitats as older juveniles (NMFS and USFWS 2013b). Hawksbills are thought to have a mixed migration strategy where some turtles remain close to their rookery and other are highly mobile, traveling thousands of kilometers to foraging areas (NMFS and USFWS 2013b). Similarly, loggerhead turtle hatchlings and early juveniles live in the open ocean before moving to nearshore foraging habitats close to their birth area (Musick and Limpus 1997). They may use the same nearshore habitat as juveniles or may move among different areas before settling in an adult coastal foraging habitat (Godley et al. 2003).

Leatherback and olive ridley turtles spend the majority of the non-breeding portion of their life cycles in the open ocean (NMFS and USFWS 2013c, NMFS and USFWS 2014). Leatherbacks are more temperate in distribution, extending to waters as far north as the Gulf of Alaska (NMFS and USFWS 2013c), while olive ridleys are found in tropical waters (NMFS and USFWS 2014). Both of these species are known to make extensive migrations through the North Pacific and are likely to occur in some portion of the BOA. While hatchlings distribution is likely determined by passive drift, juveniles begin to actively swim toward warmer latitudes during winter and higher latitudes during spring (NMFS and USFWS 2013c). Little is known about olive ridley turtles in the ROI, but available information suggests that olive ridleys traverse through the oceanic waters surrounding the Hawaiian Islands during foraging and developmental migrations (Polovina et al. 2004). The abundance of leatherbacks and olive ridleys is likely very low in the BOA with concentrations near highly productive areas (NMFS and USFWS 2014) that vary seasonally and with changing ocean conditions.

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

Fish. Fish are vital components of the marine ecosystem. They have great ecological and economic importance. The major fisheries in the Central Pacific include several tuna species, marlin, swordfish, sharks, dolphinfish, and wahoo (*Acanthocybium solandri*; Lawseth 2007). Due to the large size of the BOA, there are a diversity of oceanic habitats for fish from epipelagic to deep benthic and seamount habitats, and therefore a wide diversity of fish species. Two ESA listed species have the potential to occur in the BOA: the oceanic whitetip shark (*Carcharhinus* *longimanus*) and oceanic giant manta ray. No critical habitat for any fish species is found in the ROI. Because the BOA is entirely outside of the U.S. EEZ, no essential fish habitat occurs in the BOA ROI.

The oceanic whitetip is a highly migratory species and is one of the most widespread shark species in tropical and subtropical waters of the world (Young et al. 2018). This species is found in waters between 30°N and 35°S latitude; however, the species prefers open ocean waters between 10°N and 10°S (Young et al. 2018). The oceanic whitetip is found throughout the western and central Pacific Ocean including the Hawaiian Islands (Young et al. 2018). While these sharks may occasionally be found in coastal waters, they are usually found far offshore in the open ocean, on the outer continental shelf, or around oceanic islands in deeper waters (Young et al. 2018).

The oceanic giant manta ray is commonly sighted along productive coastlines with upwelling, but primarily occurs near offshore pinnacles and seamounts (Marshall et al. 2011). This species is thought to spend the majority of its time in deep water, with occasional visits to coastal areas (Defenders of Wildlife 2015). While oceanic giant manta rays are known to occur in the ROI, densities, distributions, and migratory patterns for this area are poorly known.

Invertebrates. Given the large spatial extent of the BOA, there are a diversity of pelagic and benthic habitats for invertebrates. Waters beyond the EEZs are usually beyond the continental shelves and are mostly very deep waters (1–6 km [0.6–3.7 mi] deep; UNEP 2006). The greatest diversity of invertebrates in these waters occurs in the epipelagic zone where available sunlight enables primary production by phytoplankton and algae. Hotspots for diversity tend to occur near underwater features such as seamounts, submarine canyons, and shelf breaks where upwelling occurs, as well as in areas where warm and cold-water currents converge (UNEP 2006). Deep-water benthic habitats also support a diversity of invertebrates including echinoderms, sponges, tube worms, anemones, mollusks, and crustaceans (UNEP 2006). While many species of deepwater benthic and pelagic invertebrates are likely to occur in the Pacific Ocean BOA, the density and distribution of these organisms are largely unknown.

At various times of the year, the gametes (eggs and sperm) and larvae of marine invertebrates may also occur in the BOA portion of the ROI. The densities of these larvae are difficult to predict, but because of the relatively large distances between most reefs and the BOA, larval density in the BOA is likely to be low. It is extremely unlikely that the shallow-water reef-associated larvae of special status invertebrate species would occur in spent test series 1 component drop zones in the BOA because they are so far up current from sources of larvae.

3.5 U.S. Army Garrison–Kwajalein Atoll – Illeginni Islet

This section includes detailed descriptions of cultural resources, biological resources, noise, public health and safety, and hazardous materials and wastes. Potential impacts to all other resource areas within this geographical area are considered to be negligible or non-existent, so they were not analyzed in detail in this EA/OEA. As the ARRW test series 1 would splash down within the BOA, only potential impacts associated with the ARRW test series 2 are discussed in this section.

3.5.1 Water Resources

Illeginni Islet has no surface water; groundwater is very limited in quantity and is saline and non-potable. Fresh water used to minimize fugitive dust following impact would not be allowed to flow to the lagoon or ocean and would evaporate in place. In the unlikely event of an accidental release of a hazardous material or petroleum product at the impact site, emergency response personnel would comply with the UES and the KEEP.

Potential impacts to water resources associated with hazardous wastes and materials are addressed in **Section 3.5.10**. No impacts to water resources would be expected.

3.5.2 Geological Resources

There would be no quarrying and little, if any, surface disturbance during the placement of equipment prior to the flight tests. While a temporary crater would be created at impact of the ARRW test series 2 vehicle on Illeginni Islet, the crater would be refilled with ejecta and clean fill materials, and the site topography restored. For a deep-water impact, there would be no marine sediment disturbance beyond the settling of the spent stage and shroud as they come to rest on the sea floor after splashing into the ocean.

Potential impacts to geological resources associated with hazardous wastes and materials are addressed in **Section 3.5.10**. No impacts to geological resources or marine sediments from the ARRW test series 2 flight tests and impacts are expected**.**

3.5.3 Cultural Resources

Cultural resources are material remains of human activity that are significant in the history, prehistory, architecture, or archaeology of the RMI. They include prehistoric resources (produced by preliterate indigenous people) and historic resources (produced since the advent of written records).

3.5.3.1 Regulatory Setting

The UES Standards for Cultural Resources (UES § 3-7) are derived from the NHPA. The Act establishes federal responsibilities and implementing regulations in 36 CFR 800 and in the U.S.

Archaeological and Historic Preservation Act (Public Law 93-291). The regulations for promoting cultural preservation that are in the RMI's Historic Preservation Act 1991 (45 Marshall Islands Revised Code, Chapter 2) were considered in developing UES § 3-7. (UES § 1-5.9)

The Standards for Cultural Resources are similar, with a few exceptions, to the U.S. statutes and regulations on which they are based. Under the UES, the U.S. Advisory Council on Historic Preservation (ACHP) does not have a formal role but may be used as a resource by the RMI Historic Preservation Officer (RMIHPO). The RMI ACHP reviews documentation of interaction between USAG-KA and RMIEPA in certain instances and may be called upon to mediate disagreements between the RMIHPO and the Commander, USAG-KA. Under the Standards, the RMIHPO executes the function of the state historic preservation office. All communication between USAG-KA and the RMIHPO is conducted through RMIEPA. The Standards substitute the RMI NRHP and its listing criteria for the corresponding U.S. Register and listing criteria.

A programmatic DEP (current version – Cultural Resources DEP 2006) on protecting cultural resources at USAG-KA addresses the potential effects of routine operations at USAG-KA on cultural resources and the procedures for identifying potential cultural resources in areas where they are not known. The Cultural Resources DEP also establishes mitigation procedures for all adverse effects on previously unidentified cultural resources. For proposed activities not covered by the Cultural Resources DEP, a specific DEP that discusses the potential for effects on cultural resources is required. The USAF would complete an NPA and a DEP for the ARRW test series 2 flight tests that addresses all applicable areas of the UES.

3.5.3.2 Region of Influence – Illeginni Islet (Preferred Impact Location)

The ROI includes those areas on Illeginni Islet where ARRW test series 2 flight test activities would occur. Surface cover from construction of a helipad, roads, and facilities, and operational disturbances encompass almost the entirety of Illeginni Islet. Vegetative cover is moderate in some areas and represents regrowth since the early 1970s construction occurred. (USAKA 2006)

Limited subsurface testing on Illeginni Islet found severe disturbance to the original land surface, especially along the lagoon-facing shoreline; most of which was bulldozed at some time in the past. With the construction of the remote launch site on the east side of the Islet and subsequent use of Illeginni as an ARRW test series 2 target impact site, any buried traditional or prehistoric remains are likely under significant amounts of modern fill.

Archaeological surveys conducted in 1988 (Craib et al. 1989) failed to identify any sites on Illeginni Island. Surveys and subsurface testing in 1994 (Panamerican Consultants Inc. 1994) identified midden-associated (refuse heap) charcoal along the lagoon shoreline that is most likely a modern intrusion; this site was not recommended as eligible for inclusion in the RMI NRHP. (USAKA 2006) No indigenous cultural materials or evidence of subsurface deposits has been found.

In September 1996, a survey of Cold War-era properties at USAG-KA was completed; a Cold War Historic Context study that built on the 1996 survey was completed in 2012. Several buildings and structures at USAG-KA are eligible for listing on the RMI NRHP under a Missile Defense Cold War context. Seven potentially eligible buildings are located on Illeginni Islet, and three of those are considered to be culturally significant. These are primarily missile launch facilities and associated buildings. The buildings and other facilities are primarily located in the central and eastern portions of the Islet. Most of them are no longer used and have been abandoned in place.

3.5.4 Land Use

No changes to land use would occur from the ARRW test series 2 flight tests. Illeginni Islet has served as the flight termination site for numerous ballistic and target test flights. The ARRW test series 2 flight test activities are consistent with the RTS mission and are well within the limits of current operations of RTS and USAG-KA.

3.5.5 Airspace

Illeginni Islet is located under international airspace and, therefore, has no formal airspace restrictions. No new special use airspace would be required, expanded, or altered for the ARRW test series 2 flight tests. Local airport operations would not be affected. Commercial and private aircraft would be notified through FAA NOTAMs in advance of the launch at the request of RTS as part of their routine operations. Flight operations would be conducted in accordance with Western Range and RTS procedures. There would be no impacts to airspace from the ARRW test series 2 flight tests.

3.5.6 Noise

This discussion of noise includes the types or sources of noise and the associated sensitive receptors in the human environment. Natural sources of noise on Kwajalein Atoll include the constant wave action along shorelines and the occasional thunderstorm. The sound of thunder is one of the loudest sounds expected at the Atoll and can register up to 120 decibels (dB). Within the Atoll communities, other noise sources include a limited number of motor vehicles, motorized equipment, and an occasional fixed- or rotary-wing aircraft. Daytime noise levels within the local communities are expected to typically range between 55 and 65 A-weighted decibels (dBA). Ambient noise levels at Kwajalein Island are slightly greater because of higher levels of equipment, vehicle, and aircraft operations; there are several aircraft flights per week there, including military and commercial jet aircraft.

Flight test vehicles can generate sonic booms during flight. The sound of a sonic boom resembles rolling thunder and is produced by a shock wave that forms at the nose and at the exhaust plume of a missile when it travels faster than the speed of sound. These shock waves produce an audible sonic boom when they reach the ground.

3.5.6.1 Regulatory Setting

The UES incorporate provisions and policies for noise management and specify conformance with the U.S. Army's Environmental Noise Management Program and noise monitoring provisions as specified in Army Regulation 200-1 (*Environmental Protection and Enhancement*). As an Army installation, USAG-KA also implements the Army's Hearing Conservation Program as described in Department of the Army Pamphlet 40-501 (*Hearing Conservation Program*). Army standards require hearing protection whenever a person is exposed to steady-state noise greater than 85 dBA, or impulse noise greater than 140 dB, regardless of duration. Army regulations also require personal hearing protection when using noise-hazardous machinery or entering hazardous noise areas.

3.5.6.2 Region of Influence – Illeginni Islet

During terminal flight and impact at RTS, the ARRW test series 2 has the potential to affect land areas with sonic booms. The ROI for noise focuses on those RMI atolls and islands potentially affected. For the Illeginni Islet ARRW test series 2 impact scenario, Kwajalein, Likiep, Ailuk, Taka, and Utirik Atolls, as well as Jemo Island, might be affected. Census records from 2011 indicate 401 residents on Likiep Atoll, 339 on Ailuk Atoll, and 435 on Utirik Atoll; and none were reported on Taka Atoll or on Jemo Island. Kwajalein Atoll has the highest population within the ROI with a total population of approximately 11,408, including U.S. personnel and Marshallese residents. (Secretariat of the Pacific Community 2011)

3.5.7 Infrastructure

There would be no changes and, therefore, no impacts to infrastructure at USAG-KA Illeginni Islet, caused by the ARRW test series 2. The Proposed Action represents activities that are consistent with the mission and well within the limits of current operations of RTS and USAG-KA.

3.5.8 Transportation

Transportation services would be unaffected by the ARRW test series 2 flight tests. Public NOTAMs and NTMs would be issued along the flight path, to include Kwajalein Atoll, to protect the safety of aircraft and vessels. The ARRW test series 2 would impact at Illeginni Islet where there is no resident population, and there would be no unauthorized vessels or aircraft in the vicinity. Transport of ARRW test series 2 flight test materials, equipment, and personnel to and from USAG-KA and the impact site would occur using existing transportation methods. ARRW test series 2 flight test activities are consistent with the mission and well within the limits of current operations of RTS and USAG-KA. There would be no impacts to transportation within RMI, at Kwajalein Atoll.

3.5.9 Public Health and Safety

RTS range safety ensures protection to Installation personnel, inhabitants of the Marshall Islands, and ships and aircraft operating in the downrange areas potentially affected by flight tests. Commercial, private, and military air and sea traffic in caution areas designated for specific flight tests or missions, and inhabitants near a flight path, are notified of potentially hazardous operations. An NTM and a NOTAM are transmitted to appropriate authorities to clear traffic from caution areas and to inform the public of impending missions. The warning messages describe the time, the area affected, and safe alternate routes. The GRMI also is informed in advance of rocket launches and reentry payload missions.

3.5.9.1 Regulatory Setting

Specific procedures based on regulations, directives, and flight safety plans are required for all missions at RTS involving aircraft, missile launches, and reentry vehicles. All program operations must first receive approval from the Safety Office at RTS. This is accomplished through presentation of the proposed program to the Safety Office. All safety analyses, standard operating procedures, and other safety documentation applicable to operations affecting RTS must be provided, along with an overview of mission objectives, support requirements, and schedule. The flight safety plans evaluate risks to inhabitants and property near the flight path, calculate trajectory and debris areas, and specify range clearance and notification procedures. Criteria used at RTS to determine debris hazard risks are in accordance with Range Commander's Council Standard 321-17, *Common Risk Criteria Standards for National Test Ranges* (RCC 2017).

3.5.9.2 Region of Influence – Illeginni Islet

The areas of Illeginni Islet where ARRW test series 2 flight test activities would occur are the ROI for land impact. Illeginni Islet is and has been the target impact location for several missile programs, including the MMIII Intercontinental Ballistic Missile (ICBM) flights. As part of USAG-KA Illeginni Islet is not open to the public. A limited number of ARRW test series 2 flight test personnel would access the Islet before the flight tests to place equipment and after the test to recover the equipment and restore the impact site. There would be no personnel on-island during the impact; project personnel would be located offshore on ships or at other islands at the time of impact.

3.5.10 Hazardous Materials and Wastes

Hazardous materials are defined by the UES referencing the U.S. Department of Transportation definition: a substance or material that is capable of posing an unreasonable risk to health, safety, or property when transported in commerce and has been so designated. Hazardous waste is defined as any solid waste not specifically excluded which meets specified concentrations of chemical constituents or has certain toxicity, ignitability, corrosivity, or reactivity characteristics.

3.5.10.1 Regulatory Setting

The UES for material and waste management (UES § 3-6) are derived from a composite of U.S. statutes and regulations addressing the use and management of hazardous material and solid waste and the RMIEPA regulations. (UES § 1-5.8)

The UES for hazardous materials and wastes differ from U.S. standards in that the UES classify all materials as either general-use, hazardous, petroleum products, or prohibited. The objective of the Standards for material and waste management is to identify, classify, and manage in an environmentally responsible way all materials imported or introduced for use at USAG-KA/RTS. Hazardous materials are subject to requirements for security, storage, and inspection at USAG-KA. Hazardous wastes must be shipped off the island. Also prohibited are all new uses of polychlorinated biphenyls (PCBs), introduction of new PCBs, and introduction of PCB articles or PCB items.

The USAG-KA base contractor manages hazardous materials and wastes through a Hazardous Materials Management Plan (UES § 3-6.4.2), which is incorporated into the KEEP (UES §3-6.4.1). The import, use, handling, and disposal procedures, records, and reporting outlined in the KEEP apply to all tenant activities at USAG-KA and the RMI as well as to the Garrison.

3.5.10.2 Region of Influence

Per the UES requirements, activity-specific Hazardous Materials Procedures are submitted by the project or mission proponents to the Commander, USAG-KA for approval within 15 days of receipt of any hazardous material or before use, whichever comes first. Hazardous materials to be used by organizations on the RTS test range and its facilities are under the direct control of the user organization, which is responsible for ensuring that these materials are stored and used in accordance with UES requirements. The use of all hazardous materials is subject to ongoing inspection by USAG-KA environmental compliance and safety offices to ensure the safe use of all materials. The majority of these materials are stored in satellite supply facilities, are distributed through the base supply system, and are consumed in operational processes.

Pollution prevention, recycling, and waste minimization activities are performed at USAG-KA in accordance with the UES and established contractor procedures are in place and managed through USAG-KA.

USAG-KA has a contingency plan (the KEEP; UES § 3-6.4.1) for responding to releases of oil, hazardous material, pollutants, and contaminants to the environment that is similar to the spill prevention, control, and countermeasures (SPCC) plan required in the United States. The UES also include a process for evaluating and, when called for, remediating sites contaminated from releases. The process is similar to U.S. Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) requirements with full participation by the public and UES Appropriate Agencies.

USAG-KA has removed all remaining hazardous materials and wastes (e.g., asbestos, PCBs in old light ballasts, and cans of paint) from buildings and facilities on Illeginni. Range personnel, generally using the unexploded ordnance (UXO) burn pit on the far west side of the Islet, also ensure that any UXO or material is consumed with each burn operation. Due to the intermittent nature of flight testing and consequent occupancy of Illeginni Islet, only small quantities of hazardous wastes are generated and managed at Illeginni Islet.

Hazardous waste, whether generated by Installation activities or RTS users, is collected at individual work sites in waste containers. Containers are labeled in accordance with the waste which they contain and are dated the day that the first waste is collected in the container. Containers are kept at the point of generation until full or until a specified time limit is reached. Once full, containers are collected from the generation point within 72 hours and are prepared for transport to the Hazardous Waste Storage Facility (Building 1521) on Kwajalein. Each of the accumulation sites is designed to handle hazardous waste and provide the ability to contain any accidental spills of material, including spills of full containers, until appropriate cleanup can be completed.

Hazardous handling and disposal activities are closely monitored by the USAG-KA Environmental Office in accordance with Standard Practice Instruction 1534 (Management of Materials, Wastes, and Petroleum Products). Waste treatment or disposal is not allowed at the Installation under the UES.

Because of previous reentry vehicle tests on Illeginni Islet, residual concentrations of beryllium and depleted uranium remain in the soil near the helipad on the west side of the Islet. In 2005, Lawrence Livermore National Laboratory (LLNL) analyzed over 100 soil samples collected around the helipad to determine concentrations of beryllium and depleted uranium in the soil (Robison et al. 2006). Soil samples were collected again following subsequent flight tests, and results were reported in 2010 and 2013 (Robison et al. 2010, 2013). The observed soil concentrations of beryllium and uranium (as a surrogate for depleted uranium) on Illeginni Islet are within compliance with USEPA Region 9 Preliminary Remediation Goals as outlined in the UES.

Tungsten was originally considered a stable metal in soil that does not dissolve easily in water. However, tungsten-contaminated environmental media are now a growing concern to USEPA and the DOD because recent research indicates that tungsten may not be as stable as was indicated in earlier studies. Furthermore, varying soil properties such as pH may cause tungsten to dissolve and leach from soil into underlying aquifers (USEPA 2014).

Prior to and following the U.S. Navy FE-1 flight test and impact on Illeginni Islet, soil samples were taken to determine the level of tungsten in the soil. Initial results indicate the average level of tungsten in the soil prior to the FE-1 test was 1.3 milligrams per kilogram (mg/kg) (range of 0.2 to 8.5 mg/kg) and an average of 3.0 mg/kg (range of 0.7 to 9.0 mg/kg) in the soil following the test.

The USEPA Regional Screening Levels (RSL) for tungsten is 63 mg/kg for residential areas and 930 mg/kg for industrial areas. Some preliminary computer modeling developed for the FE-1 flight test estimated an average concentration of tungsten in the soil to be 6.5 mg/kg.

Water samples collected in the impact crater shortly after the FE-1 test have tungsten concentrations of 0.65 milligram per liter (mg/L) (range of 0.64 to 0.67 mg/L). These values are well above the USEPA RSL for tap water (0.016 mg/L tungsten). With respect to predicting tungsten release to groundwater, it was estimated in the original LLNL reactive transport model that the tungsten groundwater concentrations would fall at or below the EPA RSL of 16 ug/L. However, this predicted concentration is strongly dependent on the spatial distribution of tungsten, the surface area of the tungsten, and the estimated annual precipitation on the Islet. Tungsten concentration in subsurface waters may be higher than the EPA RSL under certain event conditions. The high concentrations observed in the crater bottom shortly after the FE-1 test may reflect the dissolution of high surface area particulate tungsten in the crater.

The tungsten concentration in water was estimated from a combination of experimental observation (column experiments) and modeling results. Column experiments quantified the rates of tungsten dissolution and degree of tungsten sorption to carbonate material, which were then used to calibrate the CrunchFlow model. The calibrated dissolution rate and sorption affinity were then used in a simple one-dimensional model of the area of tungsten deposition to estimate tungsten concentrations in the water zone just below the zone of tungsten deposition in soil. Shortly after tungsten is deposited in the carbonate soil and rainfall begins the dissolution process, aqueous tungsten concentrations increase; with regular precipitation (assumed at 2.5 m/year [8.2 ft/year]) the concentrations reach a steady state in less than 1 year and remain constant for the following 25 years, the period for which the model was run. The steady state concentration is primarily controlled by the rate of tungsten alloy dissolution and the rate of precipitation on the island. Based on the model parameters estimated aqueous tungsten concentrations would be between 0.006 mg/L (at a dissolution rate of 1.0 milligram per square meter per hour [$mg/m^2/hr$]) and 0.015 mg/L (at a dissolution rate of 2.6 $mg/m^2/hr$). These results both fall below the USEPA Residential RSL of 0.016 mg/L. It is not known whether a freshwater lens exists in the subsurface at Illeginni Islet; however, due to lack of population and no water supply wells being located at Illeginni Islet, the presence of tungsten would not have any adverse environmental impact.

3.5.11 Socioeconomics

Use of USAG-KA by the U.S. Army is maintained under the Military Use and Operating Rights Agreement (MUORA) and Compact of Free Association, with lease payments made to the Marshallese landowners. The current lease is valid through 2066 with an additional option through 2086 (MUORA 2003). Personnel conducting the ARRW test series 2 flight tests would reside only temporarily at USAG-KA, and the ARRW test series 2 flight tests would not employ any Marshallese citizens or contribute to the local Marshallese economy. There is no resident population at Illeginni Islet. Therefore, there would be no impacts to socioeconomics from the ARRW test series 2 flight tests.

3.5.12 Environmental Justice

Illeginni Islet does not include any population centers; there is no permanent resident population at Illeginni Islet. Therefore, there would be no disproportionate impacts from the ARRW test series 2 flight tests to minority populations and low-income populations as defined under EO 12898.

3.5.13 Visual Resources

There would be no changes to and, therefore, no impacts to the visual aesthetics at USAG-KA from the ARRW test series 2 flight tests.

3.5.14 Air Quality, Greenhouse Gases, and Climate Change

Because of the relatively small numbers and types of local air-pollution sources, the dispersion caused by trade winds, and the lack of topographic features that inhibit dispersion, air quality at USAG-KA is considered good. The primary activities at USAG-KA contributing to air pollution are combustion sources that produce particulates, nitrous oxide, sulfur dioxide, carbon monoxide, and hydrocarbon emissions. (UES § 1-5.3, 2016) Most of these sources are located on Kwajalein Island and are regulated under the current version Air Emissions from Major, Synthetic Minor, and Industrial Boiler Stationary Sources Document of Environmental Protection (USAKA 2013). There are no ongoing, regulated primary air emission activities at Illeginni Islet, and there would be no change to air emissions on Kwajalein from the Proposed Action.

The ARRW test series 2 payload would not emit hazardous air pollutants (HAPs) during flight or impact in USAG-KA, and no major stationary emission sources would be involved or affected. Fugitive dust from a land impact would be temporary and quickly dispersed by trade winds. Prior to debris recovery at Illeginni Islet, the area would be wetted with freshwater to minimize fugitive dust. Although global sea level is documented to be rising based on climate change and the islands within USAG-KA are of low elevations, the subtle effects of rising sea level and climate change would not affect the flight tests after signing of the FONSI, if approved. The ARRW test series 2 flight tests would not affect climate change. No impacts to air quality or GHGs would be expected from the ARRW test series 2 flight tests.

3.5.15 Biological Resources

Biological resources described in this section are those within the affected environment at USAG-KA. The ROI includes terrestrial and shallow marine areas on or near Illeginni Islet subject to pre- and post-flight operations, ARRW test series 2 overflight, and payload impact, as well as deeper offshore marine areas of USAG-KA subject to vessel traffic and payload overflight. Consultation species on or near Illeginni Islet and in deeper offshore USAG-KA waters, including those protected under the ESA, MMPA, and UES, have been described in detail and analyzed in the USAF ARRW BA (USAF and USASMDC 2019).

3.5.15.1 Regulatory Setting

The Compact of Free Association between the RMI and the United States (48 USC § 1921) requires all U.S. Government activities at USAG-KA and all DOD and RTS activities in the RMI to conform to specific compliance requirements, coordination procedures, and environmental standards identified in the UES. As specified in Section 2-2 of the UES, these standards also apply to all activities occurring in the territorial waters of the RMI. The proposed action, which could affect Illeginni Islet, the deep-water region southwest of Illeginni Islet, or the deep ocean waters northeast of Kwajalein Atoll, must comply with the UES (USASMDC/ARSTRAT 2018).

For the purposes of this EA/OEA, special status species at USAG-KA are those species protected under the UES (USASMDC/ARSTRAT 2018) in Section 3-4. The standards in Section 3-4 of the UES were derived primarily from 50 CFR, §§ 17, 23, 402, 424, and 450-452, which includes species listed as threatened or endangered under the ESA, species protected under the MMPA, and species protected under the MBTA. The regulatory setting under the ESA, MMPA, and MBTA are described in detail in **Section 3.3.14.1** including relevant definitions under these Acts. The Marshall Islands Marine Resources Authority manages marine resources in the RMI.

The UES provides protection for a wide variety of marine mammals, sea turtles, fish, mollusks, coral species, birds, and other terrestrial and marine species, which are listed in Section 3-4 of the UES (USASMDC/ARSTRAT 2018). This protection applies to all of the following categories of biological resources occurring within the Marshall Islands, including RMI territorial waters:

- Any threatened or endangered species listed under the U.S. ESA;
- Any species proposed for designation or candidates for designation to the endangered species list in accordance with the U.S. ESA;
- All species designated by the RMI under applicable RMI statutes, such as the RMI Endangered Species Act of 1975, Marine Mammal Protection Act of 1990, Marine Resources (Trochus) Act of 1983, and the Marine Resources Authority Act of 1989;
- Marine mammals designated under the U.S. Marine Mammal Protection Act of 1972;
- Bird species pursuant to the Migratory Bird Conservation Act; and
- Species protected by the Convention on International Trade in Endangered Species (CITES), or mutually agreed on by USAG-KA, USFWS, NMFS, and the RMI Government as being designated as protected species (USASMDC/ARSTRAT 2018).

Under the UES, any action carried out at USAG-KA must be reviewed to determine if the action may affect UES listed species. If consultation is necessary, USFWS and NMFS are responsible for completing consultations. In compliance with Section 3-4 of the UES, a BA was prepared (USAF and USASMDC 2019) to analyze the effects of the ARRW tests on species listed as consultation species in the UES. This BA was submitted to the USFWS for concurrence with a "may affect but not likely to adversely affect" determination for species under the jurisdiction of the USFWS. A BA was also submitted to NMFS to initiate formal consultation on several marine species which may be adversely affected by the action, and a Biological Opinion was rendered by NMFS on 30 July 2019 (NMFS 2019; **Appendix C**).

3.5.15.2 Biological Resources in the Illeginni Islet Region of Influence

For the purposes of this EA/OEA, biological resources at Illeginni Islet are those that have the potential to be in the area subject to direct contact, exposure to hazardous chemicals, exposure to elevated noise levels, or exposure to human activity and equipment operation during ARRW activities. Special status species at Illeginni Islet are discussed in the appropriate sections below. All species requiring consultation under the UES including those protected under the ESA and MMPA, have been described in detail and environmental consequences of the ARRW program have been analyzed in the USAF ARRW BA (USAF and USASMDC 2019).

Terrestrial Vegetation at Illeginni Islet

Vegetation on Illeginni Islet is previously disturbed and managed on much of the western end of the islet, including the payload impact zone, and around buildings/facilities. Native vegetation present on the islet consists of one patch of herbaceous vegetation and three patches of littoral (near shore) forest (**Figure 3-4**). The forest areas are made up primarily of *Pisonia*, *Intsia*, *Tournefortia*, and *Guettarda* trees. Some littoral shrub habitat can also be found, mostly on the western end of the islet (USAF 2010; USFWS 2011a). No vegetation species of special status occur on Illeginni Islet.

Terrestrial Wildlife at Illeginni Islet

Terrestrial wildlife on Illeginni Islet are limited to seabirds, shorebirds, and potentially nesting sea turtles.

Sea Turtles. Suitable sea turtle haulout and nesting habitat exists on the northwestern and eastern beaches of Illeginni Islet (**Figure 3-4**). In a 2008 survey of Illeginni Islet, suitable nesting habitat for sea turtles was identified, consisting of relatively open sandy beaches and seaward margins of herbaceous strand above tidal influence (**Figure 3-4**; USFWS 2011a). These areas were thoroughly surveyed on foot for nesting pits and tracks, but none were found. These nesting and haulout habitats were reevaluated during the 2010 inventory (USFWS and NMFS 2012) and were determined to still be suitable habitat. However, the last known sea turtle nest pits on Illeginni were recorded in 1996 on the northern tip of the islet. No sea turtle nests or nesting activity have been observed on Illeginni in over 20 years. While green and hawksbill turtles are known to use the nearshore waters of Illeginni Islet it is unlikely that sea turtles will haul out or nest on Illeginni Islet.

Figure 3-4. Terrestrial Habitats, Notional Payload Impact Zone, and Nearshore Direct Contact Areas of Potential Effect at Illeginni Islet, Kwajalein Atoll, Republic of the Marshall Islands.

While sea turtles are unlikely to nest on Illeginni Islet, sea turtles are known to nest throughout the RMI. Based on available information, NMFS and USFWS (2015) estimated 300 nesting green turtle females in the RMI out of a total of 6,500 nesting females in the Central West Pacific DPS (4.6% of known breeding population). Green sea turtles have been observed hauling out and nesting at the northeastern portion of Kwajalein Islet, including the lagoon side at Emon Beach and the sand berm on the ocean side, approximately east of Emon Beach. In May 2009, a hawksbill nested on the lagoon side of Omelek Islet near the harbor area (Malone 2009). The eggs hatched in early July and were inventoried. Thirteen unhatched eggs and 101 hatched eggs were counted. Three sea turtle nests (species unidentified) were found at Kwajalein Islet in

September and October 2019. The three nests were excavated after the eggs hatched, and the numbers of hatched and unhatched eggs were estimated as less than 300 eggs. Successful sea turtle nesting on Eniwetak was confirmed by video recordings of turtle hatchlings entering the ocean at the islet in May 2011 (Aljure 2016). Successful nesting was also observed on Kwajalein Islet in January 2015 when hatchlings were found and returned to the beach or ocean (Aljure 2016). Observations of potential turtle haul-outs within Kwajalein Atoll include a lagoon-side observation at Legan in May 2013, one at Eniwetak in March 2014, two haul-outs on the ocean-side of Kwajalein Islet in 2014, and two at Eniwetak in December 2014 (Aljure 2016). The most significant green turtle nesting assemblage in RMI is in Bikar Atoll, in the northeastern corner of RMI.

Birds. A number of protected migratory and resident seabirds and shorebirds have been seen breeding, roosting, or foraging on Illeginni Islet (**Table 3-5**). Biological inventories conducted on the islet by the USFWS and NMFS have identified at least 14 bird species, including the black noddy (*Anous tenuirostris minutus*), Pacific golden plover (*Pluvialis fulva*), wandering tattler (*Heteroscelus incanus*), and ruddy turnstone (*Arenaria interpres*; **Table 3-5**). All of these birds are protected under the MBTA. Birds protected under the MBTA within USAG-KA receive protection under the UES. None of these species are currently listed under the U.S. ESA.

Table 3-5. Number of Birds Observed on Illeginni Islet During the 1998, 2000, 2002, 2004, 2006, 2008, and 2010 Biological Inventories.

Common Name	Scientific Name	Year						
		1998	2000	2002	2004	2006	2008	2010
Great frigatebird	*Fregata minor*	-	-	-	-	1	-	-
Pacific reef heron	*Egretta sacra*	11	7	3	6	3	3	2
Pacific golden plover	*Pluvialis fulva*	59	39	24	27	41	55	15
Wandering tattler	*Heteroscelus incanus*	6	13	5	7	11	18	7
Gray-tailed tattler	*Heteroscelus brevipes*	-	-	-	-	-	-	1
Tattler spp.	*Heteroscelus* spp.	-	4	1	-	-	-	-
Whimbrel	*Numenius phaeopus*	3	3	4	2	-	4	9
Bristle-thighed curlew	*Numenius tahitiensis*	-	2	-	-	1	2	-
Godwit Sp.	*Limosa*	2	-	-	-	-	-	-
Ruddy turnstone	*Arenaria interpres*	27	3	9	19	57	49	75
Black-naped tern	*Sterna sumatrana*	8	29	24	11	13	31	1
Great crested tern	*Sterna bergii*	5	3	2	1	10	4	3
Brown noddy	*Anous stolidus*	2	4	186	1	36	15	39
Black noddy, adults (nests)	*Anous tenuirostris minutus*	90	292	135	326 (130)	378	- (339)	108 (30)
White tern	*Gygis alba*	14	15	4	5	26	14	-

Source: USFWS and NMFS 2012

Surveys have shown shorebirds to use the littoral forest, littoral shrub, and managed vegetation throughout the islet's interior (**Figure 3-4**; USFWS and NMFS 2012). Pooled water on the paved areas attracts both wintering shorebirds and some seabirds (e.g., terns and plovers). White terns have been observed in trees at the northwest corner and southwestern portion of the islet. The shoreline embankment and exposed inner reef provides a roosting habitat for great crested terns (*Sterna bergii*) and black-naped terns (USFWS and NMFS 2012). Black-naped tern nests with eggs and/or chicks were recorded on Illeginni in 2012 and 2014, and these birds are known to nest in the vicinity of the impact area (Fry 2017). Concentrations of seabirds have also been seen in the littoral forest on the southeast side of the islet, which supports the second largest nesting colony of black noddies recorded on the USAG-KA islets; 339 nests were identified in 2008. In general, the nesting season for seabirds and shorebirds at Illeginni and other USAG-KA islets begins in October and continues through April. Exceptions include white terns, which may nest throughout the year (USAF 2010; USFWS 2011a) and black-naped terns, which are known to nest in March and October/November but may nest throughout the year (Fry 2017). These migratory and resident bird species are considered coordination species under the UES. There are no known consultation bird species present on Illeginni Islet.

Marine Vegetation at Illeginni Islet

Marine habitats of the neritic zone around Illeginni Islet include both lagoon-side and ocean-side reef flats, crests, and slopes with diverse communities of organisms as well as areas of pavement and cobbles. These areas provide habitat for several macroalgae species. Surveys of Illeginni Harbor in 2014 (NMFS and USFWS 2017) included observations of blue-green (*Lungbya*), green (*Boodlea, Caulerpa, Neomeris, Halimeda, Rhipilia, Rhipidosiphon,* and *Udotea*), brown (*Dictyota*), and red (*Acrochaetium, Amphiroa, Hydrolithon, Dichotomaria, Gelidiopsis, Sporolithon,* and *Anotrichium*) algae. Seagrass (*Halophila gaudichaudii*), was also in the Illeginni Harbor as well as down the slopes and near the harbor entrance, where it forms dense and relatively extensive beds (NMFS and USFWS 2017). At Kwajalein Atoll, seagrass is listed as a coordination species under the UES. Seagrass beds are important foraging areas for green sea turtles. In addition to Illeginni Harbor, seagrass beds have also been recorded at Roi-Namur harbor and in the barge slip ramp area at Kwajalein Islet.

Marine Wildlife at Illeginni Islet

The marine environment surrounding Illeginni Islet supports a diverse community of fish, corals, and other invertebrates. In general, coral cover and invertebrate diversity is moderate to high on the lagoon reef slopes and around the eastern seaward reef crest and slopes as well as off the seaward western side. While portions of the western seaward reef area are pavement and cobble with limited diversity and abundance of marine wildlife, much of the area has reef flats and ridges with dense assemblages of corals and other marine organisms. This section describes marine wildlife in shallow water habitats near Illeginni Islet in the direct contact area of potential effect, as well as in deeper offshore areas of Kwajalein Atoll which may be subject to elevated sound levels and vessel traffic. All special status species described below are protected under the UES.

Marine Mammals. Marine mammals do not occur in the shallow waters of the direct contact area near Illeginni Islet. In the deeper offshore waters near Illeginni Islet, 11 cetacean species are considered likely to occur and four other cetacean species have the potential to occur (**Table 3-6**). These marine mammals (**Table 3-6**) may occur in deeper waters areas subject to increased vessel activity and elevated sound pressure levels (SPLs). All marine mammal species are protected under the MMPA and the UES. These species have been described in detail and environmental consequences of the ARRW program have been analyzed in the USAF ARRW BA (USAF and USASMDC 2019). The density of most marine mammal species are expected to be very low in the deep waters near Illeginni Islet, although sperm whales have been observed in the vicinity of Illeginni Islet on many occasions (USAF and USASMDC 2019). Potential threats to cetaceans near Illeginni Islet and hearing ability of these species are the same as for those species in other portions of the ROI (**Section 3.3.14.2**).

Table 3-6. Special Status Species known to Occur or Potentially Occur in Shallow Waters Near Illeginni Islet or in Deeper Offshore Waters of Kwajalein Atoll.[1]

Common Name	Scientific Name	Listing Status	Likelihood of Occurrence in Nearshore Waters	Likelihood of Occurrence in Deeper Offshore Waters
Marine Mammals				
Minke whale	*Balaenoptera acutorostrata*	MMPA	-	L
Sei whale	*B. borealis*	E, MMPA	-	P
Bryde's whale	*B. edeni*	MMPA	-	L
Blue whale	*B. musculus*	E, MMPA	-	P
Fin whale	*B. physalus*	E, MMPA	-	P
Short-beaked common dolphin	*Delphinus delphis*	MMPA	-	L
Short-finned pilot whale	*Globicephala macrorhynchus*	MMPA	-	L
Humpback whale	*Megaptera novaeangliae*	E, MMPA	-	P
Killer whale	*Orcinus orca*	MMPA	-	L
Melon-headed whale	*Peponocephala electra*	MMPA	-	L
Sperm whale	*Physeter macrocephalus*	E, MMPA	-	L
Pantropical spotted dolphin	*Stenella attenuata*	MMPA	-	L
Striped dolphin	*S. coeruleoalba*	MMPA	-	L
Spinner dolphin	*S. longirostris*	MMPA	-	L
Bottlenose dolphin	*Tursiops truncatus*	MMPA	-	L
Sea Turtles				
Green turtle	*Chelonia mydas*	T	P	L
Hawksbill turtle	*Enetmochelys imbricata*	E	P	L

Common Name	Scientific Name	Listing Status	Likelihood of Occurrence in Nearshore Waters	Likelihood of Occurrence in Deeper Offshore Waters
Fish				
Bigeye thresher shark	*Alopias superciliosus*	UES	-	P
Bumphead parrotfish	*Bolbometopon muricatum*	UES	U	-
Oceanic whitetip shark	*Carcharhinus longimanus*	T	-	P
Humphead wrasse	*Cheilinus undulatus*	UES	L	-
Reef manta ray	*Manta alfredi*	UES	P	P
Oceanic giant manta ray	*M. birostris*	T	P	L
Giant coral trout	*Plectropomus laevis*	UES	L	-
Scalloped hammerhead shark	*Sphyrna lewini*	T	-	L
Pacific bluefin tuna	*Thunnus orientalis*	UES	-	P

Abbreviations: MMPA = Marine Mammal Protection Act; E = ESA endangered; T = ESA threatened; UES = UES protection (USASMDC/ARSTRAT 2018 Section 3-4.5.1); L = Likely; P = Potential; "-" = Unlikely or does not occur in this area.
[1] All ESA and MMPA listed species are also considered consultation species under the UES.

Sea Turtles. Only green and hawksbill turtles are known to occur in the waters of the RMI. Green turtles are more common, while hawksbills are considered rare or scarce (Maison et al. 2010). During the 2010 marine inventory at Illeginni, four adult green turtles were observed at three of four survey stations (USFWS and NMFS 2012). During 2014 marine inventories of harbors on Kwajalein Atoll islets, green turtles were only observed in one harbor, and this was at Illeginni Islet (NMFS and USFWS 2017). The 2014 survey recorded dense seagrass beds on the harbor bottom (NMFS and USFWS 2017), which may provide foraging habitat for green turtles. The USFWS and NOAA Fisheries share federal jurisdiction for sea turtles, with the USFWS having lead responsibility on the nesting beaches and NOAA Fisheries in the marine environment.

In addition to the threats all sea turtle species face throughout their ranges (**Section 3.3.14.2**), sea turtles near Kwajalein Atoll have the potential to be affected by local factors. In the RMI, sea turtles are an important part of Marshallese culture; they are featured in many myths, legends, and traditions, where they are revered as sacred animals. Eating turtle meat and eggs on special occasions remains a prominent part of the culture. Presently, despite national and international protection as endangered species, marine turtles remain prestigious and a highly desired source of food in the RMI (Kabua and Edwards 2010). Turtles have long been a food source in the RMI, though the level of exploitation is unknown. Direct harvest of eggs and nesting adult females from beaches, as well as direct hunting of turtles in foraging areas, continues in many areas. The harvest of sea turtles in the RMI is regulated by the RMI Marine Resources Act, which sets minimum size limits for greens (86 cm [34 in.] carapace length) and hawksbills (69 cm [27 in.] carapace length) and closed seasons from June 1 to August 31 and December 1 to January 31. Egg collecting and take of turtles while they are onshore is prohibited (Kabua and Edwards 2010).

Sea turtles' long-life expectancy and site fidelity may make them vulnerable to chronic exposure to marine contaminants (Woodrom Rudrud et al. 2007). Sea turtles may also be vulnerable to the bioaccumulation of heavy metals in their tissues (Sakai et al. 2000). At this time, the amount of contaminants in the marine environment at USAG-KA has not been measured, and sea turtles in the RMI have not been tested for heavy metal levels in blood or tissues. Several studies evaluating sources and contaminants in marine waters, sediments, and organisms have been completed at USAG-KA for the USAG-KA Environmental Cleanup program. Damage to coral reefs can reduce foraging habitat for hawksbill turtles, and damage to seagrass beds and declines in seagrass distribution can reduce near shore foraging habitat for green turtles in the RMI (NMFS and USFWS 2007b, NMFS and USFWS 1991).

Fish. Many species of reef-associated fish are found in the shallow waters of Illeginni Islet. In a 2014 survey of the direct contact areas of potential effect (**Figure 3-4**), NMFS recorded 45 species of fish in the ocean-side direct contact area of potential effect and 40 species in the lagoon-side direct contact area of potential effect (National Marine Fisheries Service – Pacific Islands Regional Office [NMFS-PIRO] 2017a). The most abundant fish included Atherinid sp., *Chrysiptera brownriggii, Stethojoulis bandanensis, Halichoeres trimuculatus, H. margaritaceus,* and *Thalassoma quinquevittatum* (NMFS-PIRO 2017a). The bumphead parrotfish (*Bolbometopon muricatum*) was recorded in shallow water habitats near Kwajalein Islet in 2016 (NMFS and USFWS 2018) but has not been recorded during surveys of Illeginni Islet and is considered unlikely to occur there. While no UES consultation species were observed during surveys of the areas of potential effect, reef fish can be highly mobile species. Two consultation species, the humphead wrasse (*Cheilinus undulatus*) and a *Manta* sp., have been observed on biological inventories at Illeginni Islet and may occur in the areas of potential effect (**Table 3-7**). One UES coordination species (*Plectropomus laevis*) was observed in the ocean-side area of potential effect in 2014 and has also been recorded in reef inventories near Illeginni Islet (**Table 3-7**).

Table 3-7. Consultation and Coordination Fish Species Frequency of Occurrence Since 2010 at Biological Inventory Sites at Illeginni Islet and Throughout Kwajalein Atoll.[1] Consultation species are in Bold.

Common Name	Scientific Name	Listing Status	Frequency at Illeginni Islet (n=5)	Frequency Throughout Kwajalein Atoll (n=125)
Humphead wrasse	*Cheilinus undulatus*	UES	0.2	0.26
Manta ray	*Manta* sp.	UES	0.2	0.03
Giant coral trout	*Plectropomus laevis*	UES	0.8	0.38

Abbreviations: UES = UES protection (USASMDC/ARSTRAT 2018 Section 3-4.5.1); n = total sites surveyed
[1]Sources: USFWS and NMFS 2012, NMFS and USFWS 2013a, NMFS and USFWS 2017, NMFS and USFWS 2018. Survey sites throughout Kwajalein Atoll include the Mid-Atoll Corridor.

The humphead wrasse is found at low densities (one to eight per acre) where it occurs and is generally observed as solitary male/female pairs or in small groups of two to seven individuals (NMFS 2009). This fish occurs in coral reef regions of the Indo-Pacific in depths from 1–100 m (3–330 ft; WildEarth Guardians 2012). Both juveniles and adults utilize reef habitats. While juveniles inhabit denser coral reefs closer to shore, adults live in deeper, more open water at the edges of reefs in channels, channel slopes, and lagoon reef slopes (Donaldson and Sadovy 2001). There is limited knowledge of their movements; however, 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).

Manta rays are likely to occur near Illeginni Islet but are not known to occur in the direct contact areas of potential effect. Manta rays were observed during 2010 and 2016 inventories of Kwajalein Atoll islets (**Table 3-7**). These observations at two locations near Kwajalein Islet in 2010 and at single locations near Eniwetak, Illeginni, and Kwajalein Islets in 2016 were recorded as observations of *Manta birostris* (oceanic giant manta ray); however, reef manta rays (*Manta alfredi*) are also known to occur in Kwajalein Atoll (V. Brown personal communication 2018). No abundance data is available for manta rays in Kwajalein Atoll; however, density data for reef manta rays is available for another Pacific island with similar reef ecosystems, Guam. Data from a long-term study of the insular coral reef ecosystem of Guam resulted in an overall density estimate of less than 0.01 individuals per km^2 (Martin et al. 2016). Densities in this study ranged from 0.0 to 0.03 per km^2 with the highest densities in reef habitats predominantly covered by coral, turf, and macroalgae and in Marine Protected Areas around Guam (Martin et al. 2016).

Five special status fish species have the potential to occur in the deep waters of Kwajalein Atoll (**Table 3-6**), but only scalloped hammerhead sharks and oceanic giant manta rays are considered likely to occur in the deep waters near Illeginni Islet. Scalloped hammerhead sharks are found in nearshore areas including bays and estuaries, over continental shelves, and around coral reefs (Defenders of Wildlife 2015). While some reports of scalloped hammerhead sharks in the vicinity of Illeginni Islet are known, this species likely has a sparse and sporadic distribution near Illeginni Islet. The bigeye thresher shark (*Alopias superciliosus*), oceanic whitetip shark, and Pacific bluefin tuna are known to occur in the Marshall Islands and have been documented as being caught in local fisheries, but little is known about their abundance, distribution, or seasonality in this area. The reef manta ray is not likely to occur in deep offshore waters; however, individuals have been known to migrate further offshore. The oceanic giant manta ray is a more oceanic species and has the potential to occur in these waters.

<u>Corals</u>. The marine environment surrounding Illeginni supports a community of corals that is typical of reef ecosystems in the tropical insular Pacific. Within this community are many species of corals that are protected as consultation or coordination species under the UES. In 2014, NMFS surveyed the reef areas adjacent to the impact area at Illeginni Islet (NMFS-PIRO 2017a and 2017b). These surveys encompassed all of the lagoon-side reef area which may be at risk from payload impact and 99% of the ocean-side area of potential effect (**Figure 3-4**). Overall, NMFS recorded 36 coral species that require coordination under the UES and 7 consultation coral species (**Table 3-8**). While many other corals species exist in the reefs surrounding Illeginni Islet, these are the only species believed to be in the direct contact area of potential effect.

There are 13 additional consultation coral species that occur on the reefs near Illeginni Islet and have the potential to occur in the ROI (*Acropora aculeus, A, aspera, A. dendrum, A. tenella, A. vaughani, Montipora caliculata, Leptoseris incrustans, Pavona cactua, P. decussata, Turbinaria mesenterina, T. stellulata, Acanthastrea brevis,* and *Alveopora verilliana*; USAF and USASMDC 2019). Four of these species, *Acropora tenella, A. vaughani, Leptoseris incrustans*, and *Pavona cactus*, occur on lower reef slopes that are well below areas that may be affected by the Proposed Action. Two other species are only known to occur in Illeginni harbor, *Pavona decussata* and *Turbinaria mesenterina,* and are not known or expected to be near the impact zone on Illeginni Islet. Adults of these species are not expected to be exposed to stressors related to the payload impact.

Coral are mostly hermaphroditic broadcast spawners, releasing both male and female gametes into the water in massive numbers (Harrison et al. 1984, NOAA 2017). In many regions, spawning is a mass synchronized event where many coral species release their gametes at the same time (NOAA 2017). After fertilization of the egg, free-floating, or planktonic, larvae form (NOAA 2017). These coral planulae are carried by water currents but are also capable of swimming vertically in the water column (NOAA 2017, Hodgson 1985). Larval duration ranges from a few days to months (reviewed by Jones et al. 2009), but short durations of 3-9 days are much more common (Hughes et al. 2000, Vermeij et al. 2010). Accordingly, dispersal ranges a few tens of meters to 2,000 km (1,080 nm), but local short-distance dispersal occurs much more frequently than long-distance dispersal (Jones et al. 2009, Mumby and Steneck 2008). At certain times of the year, coral gametes, larvae, and planulae may exist in large number over reefs with densities generally decreasing as distance from the reef increases.

Table 3-8. Coral Species Requiring Consultation (Bold) and Coordination Observed in Direct Contact Areas of Potential Effect at Illeginni Islet.[1]

Family	Scientific Name	Ocean-Side Area of Potential Effect	Lagoon-Side Area of Potential Effect	Number of USAG-KA Islets Observed at (n=11)
Alcyoniidae				
	Sinularia sp.	x	-	11
Milleporidae				
	Millepora sp.	x	x	11
Helioporidae				
	Heliopora coerulea	**-**	**x**	**11**
Acroporiidae				
	Acropora abrotanoides	x	-	11
	A. austera	x	-	11
	A. digitifera	x	x	11
	A. gemmifera	x	-	11
	A. humilis	x	-	11
	A. latistella	x	-	11
	A. microclados	**x**	**-**	**11**

Family	Scientific Name	Ocean-Side Area of Potential Effect	Lagoon-Side Area of Potential Effect	Number of USAG-KA Islets Observed at (n=11)
	A. monticulosa	x	-	11
	A. nana	x	-	10
	A. nasuta	x	-	11
	A. polystoma	x	-	6
	A. robusta	x	x	10
	A. secale	x	-	11
	A. tenuis	x	x	11
	Astreopora myriophthalma	-	x	11
	Montipora aequituberculata	x	-	11
	M. digitata	-	x	9
Agariciidae				
	Gardineroseris planulata	x	x	10
	Pavona duerdeni	x	-	11
	P. varians	x	-	11
	P. venosa	-	x	11
Dendrophylliidae				
	Turbinaria reniformis	-	x	11
Faviidae				
	Cyphastrea agassizi	-	x	9
	Favia matthaii	x	-	11
	Favites abdita	-	x	10
	Favites pentagona	-	x	9
	Goniastrea edwardsi	x	-	11
	G. reniformis	x	-	10
	Leptastrea purpurea	x	x	11
	Platygyra sinesis	x	x	11
Fungiidae				
	Fungia scutaria	x	x	11
Meruliniidae				
	Hydnophora microconis	x	-	11
Mussidae				
	Symphyllia recta	x	-	10
Pocilloporiidae				
	Pocillopora damicornis	-	x	11
	P. eydouxi	x	x	11
	P. meandrina	x	-	11
	P. verrucosa	x	-	11
Poritiidae				
	Porites lobata	x	x	11
	P. lutea	x	x	11

Family	Scientific Name	Ocean-Side Area of Potential Effect	Lagoon-Side Area of Potential Effect	Number of USAG-KA Islets Observed at (n=11)
	P. rus	x	-	11

Abbreviations: x = present; - = not observed; USAG-KA = United States Army Garrison-Kwajalein Atoll
[1] All coordination and consultation coral in this table are protected under the UES. Data Source: NMFS-PIRO 2017a

Coral and other invertebrate gametes and larvae may occur in the deeper offshore waters of USAG-KA subject to increased vessel traffic and elevated sound levels from payload overflight at certain times of the year. These may include larvae and gametes of the special status species found on the reefs of Kwajalein Atoll described above. Given the distance from these sites to reef-habitat larval sources and the average time to larval settlement, larval densities in the deeper offshore waters near USAG-KA are likely to be very low during most times of the year.

There are no known species-specific threats for any particular coral species listed in **Table 3-8**, although it is conceivable that some diseases are species specific. Some groups of corals are more or less susceptible to predation and general threats. For example, the predatory crown of thorns sea star (*Acanthaster planci*) feeds preferentially, but not exclusively, on *Acropora* and *Pocillopora* species (Gulko 1998). A type of "white" disease seems to preferentially affect tabular colonies of *Acropora* (Beger et al. 2008). The aquarium industry has various taxa-specific preferences and, as one of the more profitable industries in the RMI, is a potential contributor to loss of preferred populations (Pinca et al. 2002).

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

Non-Coral Invertebrates. Typical benthic invertebrates include sea anemones, sponges, corals, sea stars, sea urchins, worms, bivalves, crabs, and many more. A diverse benthic invertebrate community exists in the shallow waters near Illeginni Islet and has been documented by biennial inventories of Illeginni Islet conducted by the NMFS and USFWS. In 2014, NMFS surveyed the reef areas adjacent to the impact area at Illeginni Islet (NMFS-PIRO 2017a and 2017b). These surveys encompassed all of the lagoon-side reef area which may be at risk from payload impact and 99% of the ocean-side area of potential effect (**Figure 3-4**). Overall, NMFS recorded three mollusk species requiring consultation and three coordination mollusk species in the direct contact areas of potential effect (**Table 3-9**). These species are the only species likely to be in the direct contact areas of potential effect at Illeginni Islet. Two other consultation species (*Tridacna gigas* and *Pinctada margaritifera*) have been recorded at Illeginni Islet reefs since 2010 and potentially occur in the ROI outside of the direct contact area of potential effect (**Table 3-9**). Three of these species (*Hippopus hippopus, Tridacna gigas*, and *T. squamosa*) are currently ESA candidate species.

All of these special status mollusk species occur on reefs throughout Kwajalein Atoll (**Table 3-9**) and on reefs throughout the Indo-Pacific. Consultations species are described in detail and evaluated with regards to the ARRW test series 2 flight tests in the ARRW BA (USAF and USASMDC 2019). Major threats for these species include habitat degradation in the form of sedimentation and pollution; harvesting for subsistence, commercial fisheries, the aquarium trade, and the curio trade; and threats from global climate change including shell degradation from ocean acidification and in the giant clams, bleaching of symbiotic zooxanthellae (Meadows 2016).

Reproduction in these mollusk species takes place by broadcast spawning of gametes, usually seasonally. Fertilization generally takes place within hours of spawning, and fertilization success decreases within hours of spawning (Neo et al. 2015); therefore, viable gametes are not likely to be found far from adult clams. Within a few days, fertilized eggs grow into planktonic larvae, which generally metamorphose and settle to the substrate within 3 to 30 days depending on the species (USAF and USASMDC 2019). In giant clams, larvae are considered the dispersal phase where ambient currents and larval swimming speed influence long-distance dispersal (Neo et al. 2015). This long-distance dispersal is limited by the time period during which larvae are able to survive before settlement/recruitment. For most giant clam species, the period from spawning to settlement is approximately 14 days (Ellis 1997, Neo et al. 2015). As with coral, other invertebrate gametes and larvae, including those of mollusks, may occur in the deeper offshore waters of USAG-KA subject to increased vessel traffic and elevated sound levels from payload overflight at certain times of the year. These may include larvae and gametes of the special status species found on the reefs of Kwajalein Atoll described above. Due to the short time between fertilization and settlement in giant clams and their time-limited dispersal capability, the abundance of giant clam larvae (especially viable larvae) is likely very low in deeper ocean waters.

Table 3-9. Mollusk Species Requiring Consultation (Bold) and Coordination Observed in Direct Contact Areas of Potential Effect and Biennial Surveys at Illeginni Islet Since 2010.[1]

Family	Scientific Name	Ocean-Side Area of Potential Effect	Lagoon-Side Area of Potential Effect	Frequency of Occurrence at Illeginni (n=5)	Number of USAG-KA Islets Observed at (n=11)
Trochiidae					
	Tectus niloticus	-	x	100 %	11
Cardiidae					
	Hippopus hippopus	x	x	40 %	11
	Tridacna gigas	-	-	40 %	11
	T. maxima	-	x	100 %	11
	T. squamosa	-	x	60%	9
Pteriidae					
	Pinctada margaritifera	-	-	20%	8
Strombidae					
	Lambis lambis	-	x	20%	11
	L. c.f. truncata	x	-	60%	11

Data Sources: NMFS-PIRO 2017a, USFWS and NMFS 2012, NMFS and USFWS 2013a, NMFS and USFWS 2017, NMFS and USFWS 2018
Abbreviations: x = present; - = not observed
[1] All coordination and consultation coral in this table are protected under the UES

Sponges are ubiquitous on the seafloor at all depths but are most common on hard bottom or reef substrates. The sponges that inhabit coral reefs range from robust species, capable of surviving wave energy and temperature extremes, to specialized species that are delicate and cryptic. The sponges that inhabit coral reefs of the RMI are generally found throughout the tropical Indo-Pacific region. All artificially planted or cultivated sponges (phylum Porifera) within the RMI are afforded protection under the RMI Marine Resources Act (USASMDC/ARSTRAT 2018) and are protected under the UES (USASMDC/ARSTRAT 2018). However, no cultivated sponges are present in the study area. No sponges are regulated by the CITES, and no sponges are protected under the ESA (USAFGSC and USASMDC/ARSTRAT 2015). There are no consultation or coordination sponges in the ROI and the sponges that inhabit the shallow-water coral reefs of the RMI are generally found throughout the Indo-Pacific (Beger et al. 2008).

4.0 Environmental Consequences

This chapter presents the potential environmental consequences of the Proposed Action and No Action Alternative when compared to the affected environment resource areas described in **Chapter 3.0**. **Sections 4.1, 4.2** and **4.3** provide a detailed discussion of the potential direct and indirect effects of implementing the Proposed Action and the No Action Alternative. **Section 4.4** provides a summary of impacts and impact avoidance measures. As discussed in **Chapter 3.0**, the information and data presented are commensurate with the importance of the potential impacts.

Additional analyses to address any concerns from EO 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations,* and EO 13045 (as amended by EO 13229 and 13296), *Federal Actions to Address Protection of Children from Environmental Health Risks and Safety Risks* are discussed in **Sections 4.1.9, 4.1.12, 4.2.9, 4.2.11, 4.3.9**, and **4.3.12**.

4.1 Point Mugu Sea Range

This section includes assessment of noise, air quality, and biological resources within PMSR for the ARRW test series 1 flight tests. The potential impacts to all other resource areas are considered to be negligible or non-existent; as such, they are identified but were not analyzed in detail in this EA/OEA. PMSR comprises 93,680 km^2 (36,000 mi^2) of ocean area. PMSR extends from less than 5.6 km (3 nm) to more than 370 km (200 nm) off the California coastline. The aerial drop and vehicle ignition may occur within the boundaries of PMSR, with the flight azimuth heading in a westerly direction, away from land, with payload impact at Illeginni Islet. Evaluation of potential impacts to resources from aircraft departure point to aerial drop are addressed in the Environmental Assessment for Increasing Routine Flight Activities, Edwards AFB, California (AFFTC 2009) and the Environmental Assessment Addressing Construction and Operation of a Weapons Storage and Maintenance Facility, Barksdale Air Force Base, Louisiana (USAF 2017).

4.1.1 Water Resources

4.1.1.1 Water Resources – No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur and there would be no change to water resources. No impacts to water resources would occur with implementation of the No Action Alternative.

4.1.1.2 Water Resources – PMSR

There are no groundwater or surface water resources within PMSR that would be affected by the ARRW test series 1 flight tests. No impacts would occur to water resources within the over-ocean flight corridor from the ARRW test series 1 flight tests.

4.1.2 Geological Resources

4.1.2.1 Geological Resources – No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur and there would be no change to geological resources. There would be no quarry or backfill operations at PMSR. Therefore, no impacts to geological resources would occur with implementation of the No Action Alternative.

4.1.2.2 Geological Resources – PMSR

Due to the nature of the aerial drop of the ARRW test series 1 vehicle from a high altitude in PMSR's airspace, no impacts to geological resources or marine sediments from the ARRW test series 1 flight tests are expected**.**

4.1.3 Cultural Resources

4.1.3.1 Cultural Resources – No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur and there would be no change to cultural resources. Therefore, no impacts to cultural resources would occur with implementation of the No Action Alternative.

4.1.3.2 Cultural Resources – PMSR

Although there are known cultural resources within PMSR, there would be no impacts to cultural resources from the ARRW test series 1 flight test, due to the tests being initiated through aerial drop and high-altitude ignition.

4.1.4 Land Use

4.1.4.1 Land Use – No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur and there would be no change to current land use. Therefore, no impacts to land use would occur with the No Action Alternative.

4.1.4.2 Land Use – PMSR

No changes to land use would occur from the ARRW test series 1 flight tests in PMSR. Therefore, no impacts to land use from the ARRW test series 1 flight tests are expected in PMSR**.**

4.1.5 Airspace

4.1.5.1 Airspace – No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur; therefore, no impacts to airspace would occur from the No Action Alternative.

4.1.5.2 Airspace – PMSR

No new special use airspace would be required, expanded, or altered for the ARRW test series 1 flight tests. Local airport operations would not be affected. Commercial and private aircraft would be notified through FAA NOTAMs in advance of the test flight as part of their routine operations. Flight operations would be conducted in accordance with Western Range procedures. There would be no impacts to airspace from the ARRW test series 1 flight tests in PMSR.

4.1.6 Noise

4.1.6.1 Noise – No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur and there would be no change to noise levels at PMSR. Therefore, no significant impacts would occur from noise with implementation of the No Action Alternative.

4.1.6.2 Noise – PMSR

The Proposed Action states that the ARRW test series 1 flight tests will occur offshore within PMSR. A sonic boom would occur in PMSR as a result of the Proposed Action, particularly when the ARRW test series 1 vehicle reaches the speed of sound. Therefore, no short-term, or long-term, significant impacts would occur from noise as a result of the ARRW test series 1 flight tests.

4.1.7 Infrastructure

4.1.7.1 Infrastructure – No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur; therefore, no impacts to infrastructure would occur from the No Action Alternative.

4.1.7.2 Infrastructure – PMSR

There would be no changes to infrastructure within PMSR. No impacts to current infrastructure would occur from the ARRW test series 1 flight tests.

4.1.8 Transportation

4.1.8.1 Transportation – No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur; therefore, no impacts to transportation would occur from the No Action Alternative.

4.1.8.2 Transportation – PMSR

Transportation services would be unaffected by the ARRW test series 1 flight tests because the aerial drop of the would occur at high altitude and offshore. There would be no impacts to transportation at PMSR.

4.1.9 Public Health and Safety

4.1.9.1 Public Health and Safety – No Action Alternative

Under the No Action Alternative, the ARRW test series 1 flight tests would not occur and there would be no change to public health and safety. Therefore, no significant impacts to public health and safety would occur with implementation of the No Action Alternative.

4.1.9.2 Public Health and Safety – PMSR

A NOTAM and an NTM are transmitted to appropriate authorities to clear commercial, private, and non-mission military vessel and aircraft traffic from caution areas and to inform the public of impending missions. The warning messages describe the time, the area affected, and safe alternate routes. If the ARRW test series 1 vehicle were to deviate from its course or should other problems occur during flight that might jeopardize public safety, the onboard FTS would be activated. This action would initiate a destruct charge causing the ARRW test series 1 vehicle to fall towards the ocean and terminate flight. The FTS would be designed to prevent debris from falling into any protected area. No inhabited land areas would be subject to unacceptable risks of falling debris. There would be no significant impacts to public health and safety from the ARRW test series 1 test flight.

4.1.10 Hazardous Materials and Wastes

4.1.10.1 Hazardous Materials and Wastes – No Action Alternative

Under the No Action Alternative, the ARRW test series 1 flight tests would not occur and there would be no change associated with hazardous materials and wastes. Therefore, no significant impacts would occur to hazardous materials and waste with implementation of the No Action Alternative.

4.1.10.2 Hazardous Materials and Wastes – PMSR

After aerial drop of the ARRW test series 1 vehicle over PMSR, the $BKNO_3$ Pyrogen igniter and aluminized HTPB (1,633 kg [3,600 lb]) would ignite and the vehicle would fly west across PMSR through the identified BOA, impacting within the BOA. Floating debris is considered unlikely; however, there is a low probability that the spent components could float on the ocean surface post-splashdown. There will be a visual verification of the splashdown area to determine if any visible, floating debris is present. Any floating debris will be recovered and properly disposed of. **Section 4.1.14.2** details the effects of the solid rocket propellent to air quality. No short-term or long-term impacts from hazardous materials or wastes are anticipated with emissions from the ARRW test series 1 flight test.

If the ARRW test series 1 vehicles onboard FTS is activated in PMSR, then it is possible for debris to fall towards the ocean. However, the FTS would be designed to prevent any debris from falling into any protected area. No inhabited land areas would be subject to unacceptable risks of falling debris. For a discussion on impacts to biological resources, see **Section 4.1.15**. No short-term or long-term impacts from hazardous materials or wastes are anticipated with the possible onboard FTS activation in PMSR.

4.1.11 Socioeconomics

4.1.11.1 Socioeconomics – No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur; therefore, no impacts to socioeconomics would occur from the No Action Alternative.

4.1.11.2 Socioeconomics – PMSR

There is no resident population at PMSR. Therefore, there would be no impacts to socioeconomics from the ARRW test series 1 flight tests.

4.1.12 Environmental Justice

4.1.12.1 Environmental Justice – No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur; therefore, no environmental justice impacts would occur from the No Action Alternative.

4.1.12.2 Environmental Justice – PMSR

PMSR does not include any population centers; there is no resident population located at PMSR. Therefore, there would be no disproportionate impacts from the ARRW test series 1 flight tests to minority populations and low-income populations as defined under EO 12898.

4.1.13 Visual Resources

4.1.13.1 Visual Resources – No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur; therefore, no impacts to visual resources would occur from the No Action Alternative.

4.1.13.2 Visual Resources – PMSR

There would be no changes to and, therefore, no impacts to the visual aesthetics at PMSR from the ARRW test series 1 flight tests.

4.1.14 Air Quality, Greenhouse Gases, and Climate Change

4.1.14.1 Air Quality – No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur; therefore, no impacts to air quality would occur from the No Action Alternative.

4.1.14.2 Air Quality – PMSR

The aerial drop by USAF aircraft of the ARRW test series 1 vehicle over PMSR is expected to take place at an altitude of 12.2 km (40,000 ft) and over the ocean, away from the coast. The effect of the Proposed Action on local PMSR air quality would be negligible because the aerial drop would take place over 914 m (3,000 ft) and therefore above the atmospheric inversion layer (U.S. Navy 2002).

The Proposed Action would introduce atomic chlorine, aluminum oxide particles, and nitrogen oxides produced from emissions of hydrogen chloride during high-temperature afterburning reactions in the exhaust plume of the solid rocket motor propellent. This can contribute to long-term ozone depletion. The Proposed Action is for several flight tests over a reasonable period of time after completion of this EA/OEA and signing of the FONSI. The short duration of the flight tests, the length of time between the flight tests, the low emissions of the rocket exhaust, and the ignition location offshore in PMSR collectively indicate that the Proposed Action would not cause any lasting effects to PMSR air quality.

4.1.15 Biological Resources

Potential environmental consequences of the Proposed Action on biological resources are evaluated based on the best available information about species distributions and in the context of the regulatory setting discussed in **Chapter 3.0**.

4.1.15.1 Evaluation Criteria – Biological Resources

This section evaluates the environmental consequences of the Proposed Action, including direct, indirect, short-term, and long-term effects, as well as the significance of potential impacts. Direct consequences are those caused by an action and occurring at the same time and place. Indirect consequences are those which are reasonably foreseeable which are caused by an action but occur later in time or farther removed in distance from proposed activities. In general, short-term impacts are those occurring over a finite period of time such as the time period required for construction activities, whereas long-term impacts are those that are likely to be persistent or recurring such as effects to permanent fixtures or operations.

Determination of the significance of potential impacts to biological resources is based on (1) the importance of the resource (i.e., threatened or endangered species; critical habitats; recreationally, commercially, ecologically, culturally, or scientifically important species); (2) the sensitivity of the resource to proposed activities; (3) the proportion of the resource that would be affected relative to its occurrence in the region; and (4) the duration of ecological ramifications. Impacts to vegetation would be considered significant if species or habitats of concern were substantially affected over relatively large areas or habitat disturbances resulted in reductions in the population size or distribution of an important species, or the introduction of invasive species to sensitive habitats. Impacts to terrestrial wildlife would be considered significant if species or habitats of concern were substantially affected over relatively large areas or disturbances resulted in reductions in the population size or distribution that might limit the ability of a local or regional population to sustain itself.

Determination of the significance of potential impacts to special status species (i.e., threatened or endangered species) or designated critical habitat is based on the sensitivity of the species or habitat to the proposed activities. Impacts would be considered significant if an unauthorized take were to occur of a federally or State of Hawaii listed species or disturbances resulted in reductions in the population size or distribution of a special status species. Impacts to critical habitats or environmentally sensitive habitats would be considered significant if these habitats were destroyed or substantially modified over relatively large areas.

Specific to EFH, the MSA defines adverse effects to EFH as any impact that reduces quality and/or quantity of EFH. Adverse effects may include direct or indirect physical, chemical or biological alterations of the waters or substrate and the loss of, or injury to, benthic organisms, prey species and their habitat and other ecosystem components, if such modifications reduce the quality and/or quantity of EFH. Adverse effects to EFH may result from actions occurring within EFH or outside of EFH and may include site-specific or habitat-wide impacts, including individual, cumulative, or synergistic consequences of actions (50 CFR 600.810).

4.1.15.2 Biological Resources – No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur and there would be no change to biological resources. Therefore, no significant impacts to biological resources would occur with implementation of the No Action Alternative.

4.1.15.3 Biological Resources – PMSR

The Proposed Action is evaluated for the potential impacts on marine biological resources in the PMSR ROI. Potential impacts of the Proposed Action in this area include exposure to elevated noise levels from vehicle ignition and overflight during ARRW test series 1 tests. No increased human activity or vessel traffic in PMSR is anticipated as part of the Proposed Action. While not planned or expected, an accident during ARRW test series 1 vehicle air-drop or ignition is possible and would result in splashdown of the ARRW vehicle; therefore, impacts from direct contact and hazardous chemical exposure are also evaluated as a worst-case scenario. The potential for the Proposed Action to affect biological resources including those special status species and habitats described in **Section 3.3.14** is evaluated in this section.

4.1.15.3.1 Potential Stressors at PMSR

The following stressors have the potential to impact biological resources at PMSR: exposure to elevated sound pressure levels, direct contact from falling components, and exposure to hazardous chemicals.

Exposure to Elevated Sound Pressure Levels

The Proposed Action has the potential to result in elevated SPLs both in-air and underwater in the PMSR ROI. The primary elements of the Proposed Action that would result in elevated SPLs are from ARRW test series 1 vehicle ignition and overflight. The potential for effects on marine wildlife due to elevated SPLs was evaluated by comparing species effect thresholds with expected SPLs for the Proposed Action.

Sound creates vibrations that travel through air or water. Sound vibrations are characterized by their frequency (generally expressed in hertz [Hz]) and amplitude, or loudness, which is quantified here using the logarithmic dB. In water, SPLs are typically referenced to a baseline of 1 micropascal (µPa), whereas in-air pressures are typically referenced to 20 µPa. Unless noted, all SPLs in this EA/OEA are presented as in-water sounds with all dB levels referenced to (re) 1 µPa. For many organisms it can be useful to distinguish between peak exposure levels (dBpeak) and total exposure over time (sound exposure level [SEL]). For some organisms, effects are compared to thresholds based on the root mean square (RMS) SPL, which is the quadratic mean sound pressure over the duration of the sound.

The ARRW vehicles would ignite after airdrop over PMSR and fly at velocities sufficient to generate sonic booms from close to air-drop and extending to payload impact in the BOA. Sonic booms create elevated pressure levels both in-air and underwater. Exact estimates of sonic boom overpressures and footprint are not known for ARRW; however, sonic boom overpressures are expected to be at their maximum shortly after air-drop, and the USAF estimates that SPLs would be no greater than 131 dB (re 20 µPa) in-air at sea level. Sound propagation into water would mean a maximum SPL of 157 dB (re 1 µPa) in-water. While the exact area of ocean surface that would be subject to these SPLs is unknown, this maximum SPL can be used to evaluate the potential for effects on biological resources at the water's surface. Overpressure (sound levels) would dissipate with increasing distance and ocean depth. The duration of these overpressures is also not known; however, it is expected to be on the order of seconds. Overflight noise would happen only once per test in any given area, with several flight tests occurring over a reasonable period of time, subsequent to signing of the FONSI.

Effect Thresholds for Consultation Species. Noise from sonic booms has the potential to affect the behavior and hearing sensitivity in marine mammals, birds, sea turtles, and fish in the PMSR ROI. Loud sounds might cause these organisms to quickly react, altering their normal behavior either briefly or more long term or may even cause physical injury. The extent of the effect depends of the frequency and intensity of the sound as well as on the hearing ability of the organism. The hearing abilities and effect thresholds for wildlife species have been detailed in several other documents (USAF and USASMDC 2019, NOAA 2018b, NMFS-PIRO 2017c, Finneran and Jenkins 2012, NMFS 2015) and are summarized in **Table 4-1**. In general, an SPL that is sufficient to cause physical injury to auditory receptors is a sound that exceeds an organism's permanent threshold shift (PTS) level. Depending on the species, higher SPLs may induce other physical injury or, in extreme cases, even death. The extent of physical injury depends on the SPL as well as the anatomy of each species.

Table 4-1. Acoustic Thresholds for PTS, TTS, and behavioral disruption from Single Exposure to Impulsive in Water Sounds in Marine Wildlife. **Peak SPL thresholds in dB re 1 μPa.**

Group	PTS threshold (dB SPL_{peak})	TTS Threshold (dB SPL_{peak})	Behavioral Disruption[1]
Low-frequency hearing cetaceans	219	213	160
Includes: *Balaenoptera acutorostrata* *B. boralis* *B. edeni*	*B. musculus* *B. physalus*	*Eschrichtius robustus* *Megaptera novaeangliae*	
Mid-frequency hearing cetaceans	230	224	160
Includes: *Berardius bairdii* *Delphinus capensis* *D. delphis* *Feresa attenuata* *Globicephala macrorhynchus* *Grampus griseus* *Indopacetus pacificus* *Lagenodelphis hosei* *Lagenorhynchus obliquidens*	*Lissodelphis borealis* *Mesoplodon carlhubbsi* *M. densirostris* *M. ginkgodens* *M. stejnegeri* *M. perini* *M. peruvianus* *Orcinus orca* *Peponocephala electra*	*Physeter macrocephalus* *Pseudorca crassidens* *Stenella attenuata* *S. coeruleoalba* *S. longirostris* *Steno bredanensis* *Tursiops truncatus* *Ziphius cavirostris*	
High-frequency hearing cetaceans	202	196	160
Includes: *Kogia breviceps* *K. sima*	*Phocoena phocoena*	*Phocoenoides dalli*	

FINAL

DISTRIBUTION A: Approved for Public Release, Distribution Unlimited.

Group	PTS threshold (dB SPL_{peak})	TTS Threshold (dB SPL_{peak})	Behavioral Disruption[1]
Phocid Pinnipeds	218	212	160
Includes: *Mirounga angustirostris*	*Neomonachus schauinslandi*	*Phoca vitulina*	
Otarid Pinnipeds	232	226	160
Includes: *Arctocephalus townsendi* *Callorhinus ursinus*	*Eumetopias jubatus*	*Zalophus californianus*	
Birds (in-water)	212 dB SEL (non-lethal injury)	UNK	UNK
Sea Turtles	230 (non-lethal injury)	224	160
Fish	229 (lethal injury)	186 dB SEL_{cum}	150 dB_{RMS}

Sources: USAF and USASMDC 2019, NOAA 2018b, NMFS-PIRO 2017c, Finneran and Jenkins 2012, NMFS 2015
Abbreviations: dB = decibels; dB re 1 μPa = decibels referenced to 1 micropascal; PTS = Permanent Threshold Shift; RMS = Root Mean Square; SEL = Sound Exposure Level; SELcum = cumulative SEL; SPLpeak = Peak Sound Pressure Level; TTS = Temporary Threshold Shift; UNK = unknown

[1] For single explosive events, behavioral disturbance is likely to be limited to a short-lived startle reaction; however, as a conservative approach, a behavioral disturbance threshold used by NMFS in recent analyses (NMFS-PIRO 2017c) for marine mammals exposed to single, impulsive events is used.

A temporary threshold shift (TTS) is when an organism is exposed to sound pressures below the threshold of physical injury but may result in temporary hearing alteration. These sound levels may impede a marine mammal's, bird's, sea turtle's, or fish's ability to hear, even after the exposure has ended, temporarily raising the threshold at which the animal can hear. TTS can temporarily impair an animal's ability to communicate, navigate, forage, and detect predators. The onset of threshold shift in hearing in cetaceans depends on the total exposure to sound energy, a function of SPL and duration of exposure. As a sound gets louder, the duration required to induce threshold shifts gets shorter (NRC 2005).

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

For assessing potential effects on marine mammals in the ROI, the revised acoustic threshold criteria from NMFS "2018 Revisions to: Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing" (NOAA 2018b) were used. The current thresholds depend on the hearing ability of marine mammals where cetaceans are separated into low-frequency, mid-frequency, and high-frequency functional hearing groups (**Table 4-1**). For pinnipeds, the current thresholds used by NMFS to evaluate the onset of PTS and TTS are different for phocids and otariids to reflect the anatomical and functional differences in phocid and otariid hearing (**Table 4-1**; NMFS 2018). For marine mammals, the revised acoustic threshold criteria used by NMFS (NOAA 2018b) include only thresholds for PTS and TTS and no criteria for behavioral effects, therefore, criteria for single exposure to impulsive sounds used by NMFS in recent analyses (NMFS-PIRO 2017c) were used.

Seabirds may be exposed to elevated SPLs in-air as well as under water. As with other organisms, auditory threshold shifts may be either permanent (PTS) or temporary (TTS). A bird's response to noise depends on many factors including life-history characteristics of the species, frequency and amplitude of the noise source, distance from the noise source, presence of visual stimuli, and previous exposure to similar sounds (U.S. Navy 2015). Few studies have examined hearing loss in seabirds; however, the current threshold standard for PTS is 140 dBA for impulsive sounds (CALTRANS 2016). There are no data available on TTS thresholds in birds (CALTRANS 2016); however, unlike most other taxa, birds have the ability to regenerate hair cells in the inner ear, which allows them to recover from auditory injury better than other species, usually within several weeks (CALTRANS 2016). A 93 dBA (in-air) threshold for physiological or behavioral disruption from continuous noise sources has been suggested as a very conservative estimate of effects in birds (Dooling and Popper 2007). While no data supported thresholds are known for impulsive sounds, the behavioral effects of this single impulsive event are expected to be limited to short-duration startle reactions. Behavioral responses to elevated SPLs in birds include behaviors such as alert behavior, startle response, avoidance behavior, and changes in vocalization (CALTRANS 2016, U.S. Navy 2015). In some cases, where noises induce behavioral response repeatedly over time, effects to birds may include chronic stress, which may compromise the overall heath and reproductive success (U.S. Navy 2015). There is some evidence that certain birds may acclimate or become habituated to noises after frequent exposure and cease to respond behaviorally (CALTRANS 2016, U.S. Navy 2015).

The physiological and behavioral effects of elevated SPLs on birds underwater is even less well known. The extent to which a bird may be injured by underwater impulsive events likely depends on the bird's size, the anatomy of the bird, and the location of the bird relative to the source of the event (NMFS 2015). The USFWS established thresholds for onset of injury to marbled murrelets (similar in size [approximately 33 cm or 13 in.] to Newell's shearwaters) from underwater explosions in the Northwest Training and Testing BO (NMFS 2015). The USFWS established an auditory injury threshold for underwater explosions of 212 dB sound exposure level (SEL) re 1 µPa/second, a barotrauma threshold of 36 Pa/sec, and a mortality threshold of 138 Pa/sec (NMFS 2015).

For sea turtles, criteria and acoustic threshold standards which have been used by the U.S. Navy for explosive sources (Finneran and Jenkins 2012) are used (**Table 4-1**) to estimate the magnitude of effect. These criteria and acoustic thresholds for sea turtles are similar to those proposed for marine mammals, and all sea turtles are placed into a single functional hearing group (Finneran and Jenkins 2012). As with marine mammals, the behavioral effects of a single explosive event on sea turtles are likely to be limited to a short-lived startle reaction. If a very conservative approach is desired, the U.S. Navy's sea turtle behavioral disturbance threshold after exposure to multiple, successive underwater impulses might be used: SEL (weighted) of 160 dB re 1 μPa^2s (Finneran and Jenkins 2012). This threshold is based on studies that indicate that behavioral disturbance may occur with SPLs of 175 to 179 dB re 1 µPa (which correspond to SELs of 163.6 to 160.4 dB re 1 μPa^2s (Finneran and Jenkins 2012).

Direct Contact and Exposure to Hazardous Chemicals

During each of the ARRW test series 1 test flights, the ARRW test series 1 system would be aerially dropped over PMSR, the motor would ignite, and the vehicle would fly westward towards the BOA. During normal test operations, no vehicle components would fall into PMSR; therefore, no direct contact or exposure to hazardous chemicals would be expected.

In the unexpected event of an air-launch or ignition accident, the ARRW vehicle with integrated payload would splash down into the ocean. While an accident is considered very unlikely, biological resources would have the potential to be impacted by direct contact from the vehicle if an accident occurred. Debris in waters deeper than the commercial diving limits would not be recovered. The ARRW vehicle would not exceed 4,535 kg (10,000 lb), 9 m (30 ft) in length, or 66 cm (26 in.) in diameter (**Table 2-1**). All components of which the vehicle and payload are composed, (**Table 2-1**) including batteries, communication equipment, and propellants, would also enter the marine environment.

Vehicle air-drop would take place at least 93 km (50 nm) from land, including from any of the Channel Islands. Therefore, no terrestrial or nearshore biological resources would be impacted by an unexpected air-drop or ignition incident.

4.1.15.3.2 Consequences for Biological Resources at PMSR

Marine Vegetation at PMSR

The proposed ARRW tests would not significantly impact marine vegetation at PMSR, and no special status vegetation species occur at PMSR. During normal operation, there would be no impacts to marine vegetation. An air-drop or ignition accident is considered very unlikely and even if it were to occur, marine vegetation would not be significantly impacted.

Marine Wildlife at PMSR

Marine Mammals. Overall, marine mammals are not expected to be impacted by any ARRW test series 1 flight test stressors at PMSR. Any realized effects would be limited to short-term startle reactions, and marine mammals would be expected to return to normal behaviors within minutes.

Elevated Sound Level Impacts. SPLs for the Proposed Action do not exceed the TTS or PTS thresholds for any group of marine mammals; therefore, no physical injury due to sound pressures is expected from the ARRW test series 1 or 2 flight tests. Maximum SPLs for ARRW flight are 157 dB in-water at the ocean surface. The threshold for behavioral disturbance in marine mammals is 160 dB; therefore, individuals would not be exposed to sound pressures at this level even if they were at the ocean surface. Given the low density of marine mammals in PMSR, it is very unlikely that individuals would be exposed to sounds loud enough to elicit a behavioral response. Any realized effects from these very short duration sounds would be limited to short-lived startle reactions, and animals would be expected to resume normal behavior quickly with no long-term or biologically meaningful physiological effects.

Direct Contact and Exposure to Hazardous Chemicals. Marine mammals are not expected to be subject to direct contact or exposure to hazardous chemicals. Under normal ARRW operations, there would be no direct contact or hazardous chemical effects. An air-drop or ignition incident is considered very unlikely and even if an incident were to occur, causing the vehicle to fall into PMSR waters, it is not likely that a marine mammal would be subject to direct contact or exposure to hazardous chemicals in these deeper waters.

Sea Turtles. Overall, sea turtles are not expected to be impacted by any ARRW test series 1 flight test stressors in the waters of PMSR. Any impacts, if realized, would likely be limited to short-term startle reactions, and sea turtles would be expected to return to normal behaviors within minutes.

Elevated Sound Level Impacts. SPLs for the ARRW flight tests would not exceed the TTS or PTS thresholds for sea turtles; therefore, no physical injury due to sound pressures is expected from the Proposed Action. Maximum SPLs for ARRW flight are 157 dB in-water at the ocean surface. The threshold for behavioral disturbance in sea turtles is 160 dB; therefore, no individuals would be exposed to sound pressures at this level even if they were at the ocean surface. Given the low density of sea turtles in PMSR, it is very unlikely that individuals would be exposed to sounds loud enough to elicit a behavioral response. Any realized effects would be limited to short-lived startle reactions, and animals would be expected to resume normal behavior quickly with no long-term or biologically meaningful physiological effects.

Direct Contact and Exposure to Hazardous Chemicals. Sea turtles are not expected to be subject to direct contact or exposure to hazardous chemicals as a result of the ARRW test series 1 flight tests. Under normal operations, there would be no direct contact or hazardous chemical effects. An air-drop or ignition incident is considered very unlikely and even if an incident were to occur, causing the vehicle to fall into PMSR waters, it is not likely that a sea turtle would be subject to direct contact or exposure to hazardous chemicals in these deeper waters.

Fish. Overall, fish are not expected to be impacted by any ARRW flight test stressors in the waters of PMSR. Any impacts, if realized, would likely be limited to short-term startle reactions, and fish would be expected to return to normal behaviors within minutes.

Elevated Sound Level Impacts. SPLs for ARRW test series 1 vehicle flight tests would not exceed the TTS or PTS thresholds for fish; therefore, no physical injury due to sound pressures is expected. Maximum SPLs for ARRW tests are 157 dB in-water at the ocean surface. Fish may be exposed to SPLs above the behavioral disturbance threshold but only within 2 m (7 ft) of the surface. Very few fish would be within this area, and it is extremely unlikely that any special status fish species would be within the area with sounds above the behavioral disturbance threshold for fish. Unlike marine mammals, which spend a significant portion of their time on the surface, fish occur at some depth below the surface, and SPLs attenuate rapidly with depth. Any realized effects would likely be limited to short-lived startle reactions, and animals would be expected to resume normal behavior quickly with no long-term or biologically meaningful physiological effects.

Direct Contact and Exposure to Hazardous Chemicals. Fish are not expected to be impacted by direct contact or exposure to hazardous chemicals as a result of the ARRW test series 1 flight tests. Under normal ARRW operations, there would be no direct contact effects or exposure to hazardous chemicals. An air-drop or ignition incident is considered very unlikely. If an incident were to occur, causing the vehicle to fall into PMSR waters, some fish might be affected by direct contact or exposure to hazardous chemicals however, it is not likely that a significant portion of the population of any species would be impacted. Given their low densities, no special status fish species would be significantly impacted by direct contact or hazardous chemicals as a result of ARRW flight tests, even in the event of an accident.

Invertebrates. Overall, marine invertebrates are not expected to be significantly impacted by any ARRW flight test stressors in the waters of PMSR.

Direct Contact and Exposure to Hazardous Chemicals. Invertebrates are not expected to be impacted by direct contact or exposure to hazardous chemicals as a result of the ARRW test series 1 flight tests. Under normal ARRW operations, there would be no direct contact effects or exposure to hazardous chemicals. An air-drop or ignition incident is considered very unlikely, and air-drops would take place at least 93 km (50 nm) from the shoreline. If an incident were to occur, causing the vehicle to fall into PMSR waters, is likely that some invertebrates would be affected by direct contact or exposure to hazardous chemicals. It is not likely that a significant portion of the population of any species would be impacted even if an air-drop incident were to occur. Given their nearshore distributions and low densities, no special status abalone species would be impacted by direct contact or hazardous chemicals as a result of ARRW test series 1 flight tests, even in the event of an accident.

Environmentally Sensitive Habitats and Protected Areas at PMSR

It is not likely that any designated critical habitat, protected area, or essential fish habitat would be impacted by the ARRW test series 1 flight tests. The ARRW air-drops would take place at least 93 km (50 nm) from land and would not impact any protected habitats such as Channel Islands National Marine Sanctuary, Channel Islands National Park, or California Coastal National Monument.

Black Abalone Critical Habitat. Given the nearshore distribution of black abalone designated critical habitat the ARRW test series 1 flight tests are not expected to impact this critical habitat in any way.

Leatherback Critical Habitat. Under normal operations, ARRW flight tests would not impact leatherback turtle designated critical habitat in any way. Even in the event of an air-drop incident in which the vehicle fell into leatherback critical habitat (which is unlikely), the direct contact and hazardous chemicals from the vehicle would not change leatherback prey densities in that critical habitat in any significant way.

Western Snowy Plover Critical Habitat. Given the terrestrial distribution of western snowy plover designated critical habitat, the ARRW flight tests are not expected to impact this critical habitat in any way.

Essential Fish Habitat (EFH). Under normal operations, the ARRW tests would not impact EFH in any way. Even in the event of an air-drop incident in which the vehicle fell into EFH (which is unlikely), the direct contact and hazardous chemicals from the vehicle would not significantly reduce the quality and/or quantity of EFH.

4.2 Broad Ocean Area

This section includes assessment of air quality and biological resources within the BOA, for the ARRW test series 1 and 2 flight tests. The potential impacts to all other resource areas are considered to be negligible or non-existent; as such, they are identified but were not analyzed in detail in this EA/OEA. Socioeconomics are not addressed within this section, due to the flight path within the BOA having no direct impact to socioeconomics for any specific region or land mass prior to impact location.

Evaluation of potential impacts to resources from aircraft departure point to aerial drop are addressed in the Environmental Assessment for Increasing Routine Flight Activities, Edwards Air Force Base, California (AFFTC 2009) and the Environmental Assessment for the Continued Use of Restricted Area R-2515, Edwards AFB (AFFTC 1998).

4.2.1 Water Resource

4.2.1.1 Water Resources in the BOA – No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur and there would be no significant impacts to water resources.

4.2.1.2 Water Resources in the BOA

There are no groundwater or surface water resources within the BOA that would be affected by the ARRW test series 1 or 2 flight tests. There would be no disturbance to ocean waters beyond the spent component, inert payload as applicable and shroud splashing into the ocean along the flight path and sinking thousands of meters (feet). There is a low probability that the spent component could float on the ocean surface post-splashdown. Floating debris is considered unlikely; however, there is a low probability that the spent component could float on the ocean surface post-splashdown. As discussed in **Section 2.4.6.1**, any floating debris will be recovered and appropriately disposed of. No impacts would occur to water resources within the over-ocean flight corridor from the ARRW test series 1 or 2 flight tests.

4.2.2 Geological Resources

4.2.2.1 Geological Resources in the BOA – No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur and there would be no significant impacts to geological resources.

4.2.2.2 Geological Resources in the BOA

There would be no drilling, mining, or construction in the open ocean associated with the ARRW test series 1 or 2 flight tests. No marine sediment disturbance beyond the settling of the spent component, inert payload as applicable and shroud as they come to rest on the sea floor would occur. There would be no impacts to geological resources or marine sediments in the BOA from the ARRW test series 1 or 2 flight tests.

4.2.3 Cultural Resources

4.2.3.1 Cultural Resources in the BOA – No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur and there would be no significant impacts to cultural resources.

4.2.3.2 Cultural Resources in the BOA

There are no identified cultural resources within the BOA; therefore, there would be no impacts to cultural resources from the ARRW test series 1 or 2 flight tests.

4.2.4 Land Use

4.2.4.1 Land Use in the BOA – No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur and there would be no significant impacts to land use.

4.2.4.2 Land Use in the BOA

The ARRW test series 1 and 2 flight paths would avoid populated land masses. There would be no changes to land use, and therefore, no impacts from the ARRW test series 1 or 2 flight tests to land use within the BOA.

4.2.5 Airspace

4.2.5.1 Airspace in the BOA – No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur and there would be no significant impacts to airspace.

4.2.5.2 Airspace in the BOA

The flight corridor is located over international airspace within the BOA and, therefore, has no formal airspace restrictions governing it. Over-ocean flight tests must comply with DOD Instruction 4540.01, Use of International Airspace by U.S. Military Aircraft and for Missile/Projectile Firings. Commercial and private aircraft would be notified through NOTAMs issued through the FAA in advance of the ARRW test series 1 and 2 flight tests at the request of RTS as part of their routine operations. ARRW test flight operations would be conducted in accordance with Western Range procedures and would not expand or alter currently controlled airspace. Therefore, there would be no impacts to airspace within the BOA from the ARRW test series 1 or 2 flight tests.

4.2.6 Noise

4.2.6.1 Noise in the BOA – No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur and there would be no significant noise impacts.

4.2.6.2 Noise in the BOA

The ARRW test series 1 and 2 flight tests would occur at an altitude where it would be generally undetected by vessels or aircraft at the ocean's surface. Sonic booms are generated following solid rocket motor ignition and during terminal impact. Only the sonic boom created by the solid rocket motor ignition would occur over the BOA. Therefore, there would be no impacts to noise within the BOA.

4.2.7 Infrastructure

4.2.7.1 Infrastructure in the BOA – No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur and there would be no significant impacts to infrastructure.

4.2.7.2 Infrastructure in the BOA

No changes would occur to infrastructure from the ARRW test series 1 or 2 flight tests; therefore, there would be no impacts to infrastructure in the BOA.

4.2.8 Transportation

4.2.8.1 Transportation in the BOA – No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur and there would be no significant impacts to transportation.

4.2.8.2 Transportation in the BOA

Transportation services would be unaffected by the ARRW test series 1 or 2 flight tests over the open ocean. The ARRW test series 1 and 2 flight tests would occur at high altitude where they would be generally undetected by vessels or aircraft. Public NOTAMs and NTMs would be issued along the flight path, between the drop and ignition point and impact point, to ensure the safety of both aircraft and vessels. Components would drop to the ocean surface within the predetermined BOA to ensure, along with the public notices, that there would be no vessels or aircraft in the vicinity. There would be no impacts from the ARRW test series 1 or 2 flight tests to transportation along the flight path over the open ocean.

4.2.9 Public Health and Safety

4.2.9.1 Public Health and Safety in the BOA – No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur and there would be no significant public health and safety impacts.

4.2.9.2 Public Health and Safety in the BOA

The ARRW test series 1 and 2 flight tests would occur at high altitudes where they would be generally undetected by vessels or aircraft. NOTAMs and NTMs would be issued along the flight path to ensure the safety of personnel on aircraft and vessels. Components would drop over predetermined open ocean areas to ensure, along with the public notices, that there would be no vessels or aircraft in the vicinities. If the ARRW test series 1 or 2 vehicles were to deviate from course or should other problems occur during flight that might jeopardize public safety, the onboard FTS would be activated. This action would initiate a destruct charge causing the ARRW test series 1 or 2 vehicles to fall towards the ocean and terminate flight. The FTS would be designed to prevent any debris from falling into any protected area. No inhabited land areas would be subject to unacceptable risks of falling debris. There would be no impacts to public health and safety associated with the ARRW test series 1 or 2 flight tests, and flight trajectory over the BOA.

4.2.10 Hazardous Materials and Wastes

4.2.10.1 Hazardous Materials and Wastes in the BOA – No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur and there would be no significant impacts from hazardous wastes and materials.

4.2.10.2 Hazardous Materials and Wastes in the BOA

During each of the ARRW test series 2 test flights, the ARRW system would be aerially dropped within the BOA, the solid rocket motor would ignite, and the vehicle would fly westward towards Illeginni Islet. During ARRW test series 1 and 2 flight tests, the rocket motor will exhaust on-board propellant prior to separation and before the spent components drop into the ocean. *De minimus* residual quantities of materials may remain on the spent components and shroud and would sink to the ocean floor. There is a low probability that the spent component could float on the ocean surface post-splashdown. Floating debris is considered unlikely; however, there is a low probability that the spent component could float on the ocean surface post-splashdown. As discussed in **Section 2.4.6.1**, any floating debris will be recovered and appropriately disposed of. There would be no impacts to hazardous materials and wastes along the over-ocean flight corridor from the ARRW test series 1 or 2 flight tests.

4.2.11 Environmental Justice

4.2.11.1 Environmental Justice in the BOA – No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur and there would be no significant impacts of environmental justice.

4.2.11.2 Environmental Justice in the BOA

Range safety regulations and procedures protective of health and safety would be applied during flight test operations. There would be no disproportionate impacts within the BOA to minority populations or low-income populations under EO 12898 from the ARRW test series 1 or 2 flight tests.

4.2.12 Visual Resources

4.2.12.1 Visual Resources in the BOA – No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur and there would be no significant visual resource impacts.

4.2.12.2 Visual Resources in the BOA

The ARRW test series 1 and 2 flight tests would occur at high altitude where it would be generally undetected by vessels or aircraft. There would be no impacts to visual resources from the ARRW test series 1 or 2 flight tests (flight path).

4.2.13 Air Quality, Global Atmosphere, and Climate Change

Effects on air quality are based on estimated direct and indirect emissions associated with the ARRW test series 1 and 2 flight tests. The ROI (within the BOA) for the ARRW test series 1 and 2 flight tests is the global upper atmosphere along the flight path from point of aerial drop and solid rocket motor ignition to outside the impact area at RTS. During flight, emissions from the ARRW test series 1 and 2 flight tests have the potential to affect air quality in the global upper atmosphere, within the BOA.

Estimated emissions from a proposed federal action are typically compared with the relevant national and state standards to assess the potential for increases in pollutant concentrations.

4.2.13.1 Air Quality in the BOA – No Action Alternative

Under the No Action Alternative, the ARRW test series 1 and 2 flight tests would not occur and there would be no change to baseline air quality. Therefore, no significant impacts to air quality or air resources would occur with implementation of the No Action Alternative.

4.2.13.2 Air Quality in the BOA

Vehicle emissions, from the ARRW test series 1 and 2 flight tests, would occur as propellant is burned from point of solid rocket motor ignition, within the BOA to splashdown within the BOA (ARRW test series 1) or impact at Illeginni Islet (ARRW test series 2). The active flight time over the ROI would be measured in minutes.

Approximately 1,633 kg (3,600 lb) of HTPB are released over a period of minutes, for the ARRW test series 1 and 2 flight tests. HTPB is long-chain, cross-linked, and high molecular-weight polymer. At temperatures below 770 Kelvin (K), the main gaseous product of HTPB is butadiene, whereas the range of products arises as the temperature increases. At 1,170 K, butadiene accounts for only 1–2% of the products, and the primary product is ethylene. Thermal decomposition of HTPB in a rocket-motor environment is assumed to undergo the following pathway:

$$\text{HTPB} \longrightarrow \text{ethylene } (C_2H_4) \text{ and light hydrocarbon species}$$

On a global scale, the quantity of ethylene and light hydrocarbon emissions from a single ARRW test series 1 or 2 flight test would represent a very small fraction of ethylene and hydrocarbons generated. Ethylene does not present a health hazard to humans or animals, as it is a naturally produced gas. Additionally, diffusion and winds would disperse the ethylene and hydrocarbons. No significant effect on ozone levels from ethylene and hydrocarbons is expected. Therefore, impacts from single ARRW test series 1 or 2 flight test would not be expected to have a significant impact on the upper atmosphere.

Tropospheric ozone concentrations are steadily rising, and ambient levels are already sufficient to impact natural ecosystems. However, rocket motor emissions from the ARRW test series 1 and 2 flight tests would not have a significant impact on stratospheric ozone depletion. Ozone-depleting gas emissions from the single flight test would represent such a minute increase that any incremental effects on the global atmosphere would be discountable and insignificant.

Impacts of the ARRW test series 1 and 2 flight tests on global warming, climate change, and ozone depletion in the atmosphere have also been considered as part of cumulative impacts in **Chapter 5.0**.

4.2.14 Biological Resources

Potential environmental consequences of the Proposed Action on biological resources are evaluated based on the best available information about species distributions and in the context of the regulatory setting discussed in **Chapter 3.0**.

4.2.14.1 Biological Resources in the BOA – No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur and there would be no change to biological resources. Therefore, no significant impacts to biological resources would occur with implementation of the No Action Alternative.

4.2.14.2 Biological Resources in the BOA

The Proposed Action is evaluated for the potential impacts on marine biological resources in the BOA of the ROI. Potential impacts of the Proposed Action in this area include exposure to ARRW stressors including elevated SPLs, direct contact from falling ARRW components, exposure to hazardous chemicals, and increased human and vessel activity. The potential for the Proposed Action to affect biological resources including those special status species described in **Section 3.4.14** is evaluated in this section. In-depth analyses of the effects of the ARRW test series 2 tests on consultation species have been completed in the ARRW BA (USAF and USASMDC 2019) and have been reviewed by NMFS in a Biological Opinion (**Appendix C**; NMFS 2019]). In general, impacts on threatened and endangered species are not expected to be different than those on non-listed species.

4.2.14.2.1 Potential Stressors in the BOA

The following stressors have the potential to impact biological resources in the BOA; exposure to elevated SPLs, direct contact from ARRW component splashdown, exposure to hazardous chemicals, and exposure to human activity and vessel traffic.

Exposure to Elevated Sound Pressure Levels

The Proposed Action has the potential to result in elevated SPLs both in-air and underwater in the BOA. The primary elements of the Proposed Action that would result in elevated SPLs in the BOA are: (1) sonic booms from ARRW vehicle test series 1 or 2 flight tests and (2) splashdown of ARRW components. The general characteristics of sound in-air and underwater as well as effect thresholds for wildlife species are discussed in **Section 4.1.15.3**.

Sonic Booms. The ARRW test series 1 and 2 test vehicles would fly at velocities sufficient to generate sonic booms from air-drop (ignition point) and extending to either payload splashdown in the BOA (for ARRW test series 1 tests) or impact at Illeginni Islet (for ARRW test series 2 tests). Sonic booms create elevated pressure levels both in-air and underwater. Exact estimates of sonic boom overpressures and footprint are not known for ARRW; however, sonic boom overpressures are expected to be at their maximum shortly after air-drop and are expected to have SPLs no greater than 131 dB (re 20 µPa) in-air at sea level. Sound propagation into water would mean a maximum SPL of 157 dB (re 1 µPa) in-water. While the exact area of ocean surface that would be subject to these SPLs is unknown, this maximum SPL can be used to evaluate the potential for effects on biological resources at the water's surface. Overpressure (sound levels) would dissipate with increasing distance and ocean depth. The duration of these overpressures is also not known; however, it is expected to be on the order of seconds. All estimates of sonic boom overpressures were calculated using assumptions that would lead to the most conservative (worst-case) estimate.

Splashdown of Spent Components. Elevated SPLs would occur in the ocean as ARRW components impact the ocean's surface. SPLs of component splashdown in ocean waters depend on the component size, shape, weight, velocity, and trajectory, as well as on air and water conditions. Estimates of SPLs resulting from splashdown of ARRW components are not available; however, actions such as FE-1, for which SPLs have been estimated (U.S. Navy and USASMDC 2017) can be compared to ARRW components (U.S. Navy and USASMDC 2017, USAF and USASMDC 2019). The ARRW test series 1 and 2 vehicle components are comparable in shape but smaller than FE-1 components. Therefore, estimate of splashdown SPLs for comparable (but larger) FE-1 spent motors and nose fairings are used as maximum bounding estimates for splashdown SPLs for the ARRW components. Based on these comparisons, the peak SPL of spent motor and fairing splashdown is estimated to be less than 201 dB (re 1 µPa) and the peak SPL for shroud splashdown would be less than 196 dB (**Table 4-2**). No estimates of payload splashdown SPLs are available for the ARRW test series 1 flight tests. The ARRW series 1 test payloads are inert and are smaller than the spent ARRW vehicle components (estimated to be about half the size; **Figure 2-1**). Therefore, payload splashdown SPLs are assumed to be lower than those of spent vehicle components (maximum SPL estimate of 201 dB) and the effects of payload splashdown noise would be less than those of component splashdown.

Table 4-2. Estimated Impact Contact Areas and Peak Sound Pressure Levels for ARRW Components in the BOA.

Component	Contact Area in square meters (square feet)	Estimated Peak Sound Pressure Level **(dB re 1 µPa)**
Spent Component (all tests)	2.8 (29.6)	201
Shroud (all tests)	1.1 (12.3)	196
Inert Payload (ARRW test series 1)	estimated 1.4 (14.8)	unknown

Sources: USAF and USASMDC 2019
Note: dB re 1 µPa = decibels referenced to 1 micropascal

Effect Thresholds for Species. The hearing abilities and effect thresholds for consultation species in the BOA were detailed in the ARRW BA (USAF and USASMDC 2019). Effect thresholds used in these analyses are discussed in **Section 4.1.15.3** and summarized in **Table 4-1**.

Methods for Estimating Elevated Sound Level Effects. For each species group, and each ARRW component, the range to threshold was calculated using the spherical spreading model:

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

where x is the spreading coefficient (x=20 for deep ocean waters and x=15 for shallow waters), and SPLs are in dB_{peak} re 1 μPa. Then an area of potential effect was calculated for each relevant threshold using:

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

The radial distance (range) from component splashdown to thresholds and the ocean surface area subject to SPLs above threshold for each group of marine organisms is presented in **Table 4-3**.

Table 4-3. Maximum Underwater Radial Distances to Thresholds and Acoustic Area of Potential Effect for Marine Mammals, Sea Turtles, and Fish from and ARRW Vehicle Component Splashdown in the BOA.

Species Group	Threshold Category	Threshold **(re 1 μPa)**	Radial Distance from Vehicle Component Splashdown Point, m (ft)		Potentially Affected Surface Area around Splashdown Point, km^2 (mi^2)	
			Test Series 1 Component	Shroud	Test Series 1 Component	Shroud
High Frequency Cetaceans	TTS	196 dB_{peak}	1.8 (5.8)	1.0 (3.3)	0.000009 (0.000003)	0.000003 (0.000001)
Marine Mammals and Sea Turtles	Behavioral Disruption	160 dB_{peak}	112.2 (368.1)	63.1 (207.0)	0.0395 (0.0153)	0.0125 (0.00048)
Fish	TTS	186 dB SEL_{cum} re 1 μPa^2-s	5.6 (18.45)	3.2 (10.4)	0.000099 (0.000038)	0.000031 (0.000012)
	Behavioral Disruption	150 dB_{RMS}	354.8 (1,164.1)	199.5 (654.6)	0.3955 (0.1527)	0.1251 (0.0483)

Abbreviations: dB = decibels; dBpeak = peak decibels; re 1 μPa = referenced to 1 micropascal; km^2 (mi^2) = square kilometers (square miles); m (ft) = meters (feet); RMS = Root Mean Square; SELcum = Cumulative Sound Exposure Level ; TTS = Temporary Threshold Shift; UNK = unknown

The number of marine mammal and sea turtle exposures to elevated SPL effects from splashdown of components was calculated based on the best-known density information for each species and the BOA. Species densities in the BOA were estimated based on the Navy's Marine Species Density Database (NMSDD; Hanser et al. 2017, U.S. Navy 2015). These density databases contain estimates of marine mammal and sea turtle density for three major areas, Mariana Islands Training and Testing (MITT) area in the western portion of the BOA, Hawaii Range Complex (HRC) in the central portion of the BOA, and Southern California (SOCAL) in the eastern portion of the BOA. The extent of the BOA was overlaid onto the NMSDD spatially explicit density files and clipped to the area of overlap between the two. The maximum average density across species was determine for each of the three portions of the BOA with density data; western (MITT density coverage), central (HRC density coverage), and eastern (SOCAL density coverage). The maximum of these average densities was used for analysis of the effects of elevated SPLs. Sea turtles in the BOA were combined into a “sea turtle guild” for analyses due to the lack of species-specific occurrence data and available density estimates in the NMSDD (Hanser et al. 2017). A beaked whale guild was used for the SOCAL portion of the NMSDD that incorporated all small beaked whale species. Since these species were treated separately in other portions of the BOA, it was assumed that the density for the beaked whale guild in SOCAL was the density for each of the species included in the guild, a conservative approach which would lead to overestimation of effects. This sea turtle guild is composed of primarily green and hawksbill turtles as they account for nearly all sightings; however, in theory, the guild also encompasses leatherback, olive ridley, and loggerhead turtles (Hanser et al. 2017). The number of exposures was calculated as species density times the area of potential effect. Density data for most fish and seabird species are not available for the BOA; therefore, estimates of the number of exposures were not possible for these species.

Direct Contact

The Proposed Action would result in spent components, shrouds, and inert payloads (ARRW test series 1 only) splashing down into the BOA. These falling components would directly impact aquatic habitats and have the potential to directly contact marine organisms. For each of the ARRW test series 1 flight tests, one spent component, one shroud, and an inert payload would splash down into the BOA. For each of the ARRW test series 2 flight tests, one spent component and one shroud would splash down into the BOA (**Figure 1-2**). The component, for each test, is 417 cm (164 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.). Maximum direct contact areas for these individual components are 2.7 m^2 (29.6 ft^2) for the component and 1.1 m^2 (12.3 ft^2) for the shroud. The exact size of the payload used during ARRW test series 1 tests is not known; however, the payloads are inert and assumed to be smaller than the spent ARRW components (estimated to be about half the size; **Figure 2-1**). Therefore, an estimated contact area of 1.4 m^2 (14.8 ft^2) is used in these analyses (**Table 4-2**).

Methods for Estimating Direct Contact Effects. Based on the size of ARRW components and the best available species density information, chances of direct contact to consultation organisms in the BOA were calculated in the ARRW BA (USAF and USASMDC 2019). Calculations were based on methodology in the FE-1 EA (U.S. Navy 2017), Mariana Islands Training and Testing Activities Final EIS (Appendix G in U.S. Navy 2015), and the Hawai`i-Southern California Training and Testing EIS (Appendix G in U.S. Navy 2013). Species densities in the BOA were estimated based on the best available scientific data incorporated in models of the NMSDD (Hanser et al. 2017). The NMSDD contains estimates of marine mammal and sea turtle density for three major areas, MITT in the western portion of the BOA, HRC in the central portion of the BOA, and SOCAL in the eastern portion of the BOA. The extent of the BOA was overlaid onto the NMSDD spatially explicit density files and clipped to the area of overlap between the two. The maximum average density across species was determine for each of the three portions of the BOA with density data; western (MITT density coverage), central (HRC density coverage), and eastern (SOCAL density coverage). The BOA is large, and marine species are not uniformly distributed across the BOA. Since marine species density data coverage is incomplete but constitutes the best available information, the spatially explicit number of animals for those BOA areas with density coverage were used and densities for the remaining portions of the BOA were extrapolated based on the portion of the BOA (western, central, or eastern). Using the spatial area of the NMSDD density data that overlapped the BOA, the maximum estimated number of individuals (across seasons), average density, and overlap area were determined for three separate portions of the BOA; western (MITT density coverage), central (HRC density coverage), and eastern (SOCAL density coverage). For each portion of the BOA, the area without spatially explicit density coverage in the NMSDD was calculated and the average (or maximum if an average was not available) density for overlap areas was used to estimate animal numbers in the non-covered areas (i.e., average of MITT area densities for the western portion, average of HRC densities for the central portion, and average of SOCAL densities for the eastern portion). These methods were also used to evaluate the effects of ARRW test series 1 flight tests.

Sea turtles were combined into a "sea turtle guild" for analyses due to the lack of species-specific occurrence data and available density estimates in the NMSDD (Hanser et al. 2017). This sea turtle guild is composed of primarily green and hawksbill turtles as they account for nearly all sightings; however, in theory, the guild also encompasses leatherback, olive ridley, and loggerhead turtles (Hanser et al. 2017). These analyses assume that all animals would be at or near the surface 100% of the time and that the animals are stationary. While these assumptions do not account for animals that spend the majority of time underwater or for any animal movement or potential avoidance to proposed activities, these assumptions should lead to a conservative estimate of direct contact effect on listed species. A beaked whale guild was used for the SOCAL portion of the NMSDD that incorporated all small beaked whale species. Since these species were treated separately in other portions of the BOA, it was assumed that the density for the beaked whale guild in SOCAL was the density for each of the species included in the guild, a conservative approach which would lead to overestimation of effects.

The probability or impact and total number of exposures were calculated for each of the splashdown scenarios, for each marine mammal or sea turtle species, and for each component (USAF and USASMDC 2019). The scenario-specific probability and exposure were averaged over the four scenarios (using equal weighting) to obtain single scenario-averaged estimates of probability and number of exposures.

Vessel Strike and Increased Human Activity

The Proposed Action has the potential to increase ocean-going vessel traffic in the BOA. The Proposed Action would result in vessel traffic in the BOA for on-board sensor placement along the flight path. A series of sensors would be onboard vessels which may include the Missile Defense Agency Pacific Collector, the MATSS, and the KMRSS on board the U.S. Motor Vessel

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

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

Exposure to Hazardous Chemicals

The Proposed Action has the potential to introduce hazardous chemicals and marine debris into the BOA. Any substances of which the ARRW test series 1 and 2 are constructed, or that are contained in the system components and are not consumed during flight (**Table 2-1**), would fall into the BOA when the components splashdown. The ARRW test series 1 and 2 vehicle components are described in **Table 2-1**. Though the batteries carried onboard the vehicles would be discharged by the time they splash down in the ocean, they would still contain small quantities of electrolyte material. These materials, along with residual amounts of solid propellant and heavy metals contained in the vehicle motor, payload or shroud, may contaminate seawater. The release of such contaminants could harm marine organisms that come in contact with, or ingest, these hazardous chemicals. Floating debris is considered unlikely; however, there is a chance that spent components could float on the ocean surface post-splashdown. As discussed in **Section 2.4.6.1**, any floating debris will be recovered and appropriately disposed of.

In an evaluation of the effects of rocket systems that are deposited in seawater, NASA concluded that the release of hazardous materials carried onboard launch vehicles would not significantly impact marine life. Materials would be rapidly diluted in the seawater and, except for the immediate vicinity of the debris, would not be found at concentrations that produce adverse effects (U.S. Navy 1998). The ARRW test series 1 and 2 are much smaller than the launch vehicles analyzed above; therefore, hazardous materials carried onboard ARRW would be fewer and even less likely to significantly impact marine life.

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

4.2.14.2.2 Consequences for Biological Resources in the BOA

Marine Wildlife in the BOA

Within the BOA, the ARRW flight tests are not expected to have a discernible or measurable impact on benthic or planktonic invertebrates because of their very low abundance, their sparse distribution, and the protective influence of the mass of the ocean around them. The potential exists, however, for effects to larger vertebrates in the open ocean area, particularly those that must come to the surface to breathe (e.g., marine mammals and sea turtles) or that feed at the surface (e.g., seabirds). Potential stressors to such species could occur from exposure to elevated noise (sonic booms and splashdown pressures), direct contact from falling components, vessel strike, and exposure to hazardous chemicals released into the water.

Marine Mammals. Overall, marine mammals are not expected to be significantly impacted by any ARRW stressors in the BOA. Any impacts, if realized, would likely be limited to short-term startle reactions and marine mammals would be expected to return to normal behaviors within minutes. The following sections present the results of analysis of potential impacts of ARRW stressors in the BOA on marine mammals.

Elevated sound level impacts: Elevated SPLs from sonic booms are not expected to impact marine mammals in the BOA as maximum SPLs for sonic booms in the BOA (157 dB re 1 μPa) do not exceed the PTS, TTS, or behavioral disturbance thresholds for cetaceans or pinnipeds.

Elevated SPLs from spent component splashdown are not expected to impact marine mammals in the BOA as the calculated chances of a marine mammal being exposed to sounds loud enough to cause temporary or permanent injury are extremely low (**Table 4-4**). Splashdown SPLs in the BOA do not exceed the PTS or TTS thresholds for cetaceans in the mid- or low-frequency hearing groups (26 species) or for pinnipeds. For cetaceans in the high-frequency hearing group, elevated sound levels might exceed the TTS threshold out only 1.8 m (5.8 ft) from component splashdown and 1.0 m (3.3 ft) from shroud splashdown. There is a 1 in 1.1×10^7 to 1 in 2.6×10^7 chance (depending on the species) of a cetacean in the high-frequency hearing group (3 species) being exposed to SPLs great enough to cause TTS for component splashdown during any given ARRW test series 1 or 2 flight test. Even if a conservative estimate (that of component splashdown) is used for payload splashdown SPLs during the ARRW test series 1 tests and added to vehicle component estimates, there is a 1 in 5.2×10^5 chance that any cetacean in the high-frequency hearing group would be exposed to SPLs high enough to elicit TTS for all ARRW test series 1 and 2 flight tests combined. Cetaceans in the high-frequency hearing group include pygmy and dwarf sperm whales as well as Hubb's beaked whale.

Cetaceans and pinnipeds may be exposed to SPLs from component splashdown high enough to elicit behavioral response. The chances of an individual marine mammal being exposed to SPL high enough to elicit behavioral response for all of the flights combined is 1 in 2 for cetaceans and 1 in 22 for pinnipeds. Even if an animal were to be exposed to SPLs above the behavioral disturbance threshold, behavioral responses would be expected to be extremely short lived, and animals are expected to resume normal behavior quickly. No biologically meaningful physiological or long-term effects would be expected.

Direct contact: Direct contact from splashdown of vehicle components is not expected to impact marine mammals in the BOA, as the calculated chances of a marine mammal being injured are extremely low. The estimated chance of a marine mammal being exposed to direct contact from falling ARRW components (for all ARRW test series 1 and 2 tests flights combined) in the BOA is between 1 in 51,400 and 1 in 16,600,000 depending on individual species (**Table 4-5**). While all possible species have been included in these analyses and extrapolated animal densities for portions of the BOA were no data were available, it is important to note that many of these species are extremely unlikely to occur in the BOA during portions of the year (**Section 3.4.14**). Even when totaled across species and all test flights, the estimated chance of any marine mammal exposure is only 1 in 7,510. The exposure estimates were modeled based on conservative assumptions, including the assumption that animals are at the surface 100 percent of the time, and likely result in an overestimation of probability of effect.

Table 4-4. Maximum Estimated Number of Marine Mammal and Sea Turtle Exposures to Acoustic Impacts from Vehicle Component Splashdown in the BOA.

Species	Maximum Average Density (/km²)[1]	Total Number of Exposures for Each Test		Total Number of Exposures for All ARRW Test Series 1 and 2 Flights	
		TTS	Behavioral Disturbance	TTS	Behavioral Disturbance
Marine Mammals					
Balaenoptera acutorostrata	0.00423	-	2.20E-04	-	0.0015
B. borealis	0.00016	-	8.33E-06	-	5.83E-05
B. edeni	0.00030	-	1.56E-05	-	0.0001
B. musculus	0.00180	-	9.35E-05	-	0.0007
B. physalus	0.00181	-	9.42E-05	-	0.0007
Delphinus delphis	0.94740	-	4.93E-02	-	0.3452
Feresa attenuata	0.00440	-	2.29E-04	-	0.0016
Globicephala macrorhynchus	0.00354	-	1.84E-04	-	0.0013
Grampus griseus	0.02187	-	1.14E-03	-	0.0080
Indopacetus pacificus	0.00310	-	1.61E-04	-	0.0011
Kogia breviceps	0.00291	3.81E-08	1.51E-04	2.66E-07	0.0011
K. sima	0.00714	9.34E-08	3.72E-04	6.54E-07	0.0026
Lagenodelphis hosei	0.02100	-	1.09E-03	-	0.0077
Lissodelphis borealis	0.13950	-	7.26E-03	-	0.0508
Megaptera novaeangliae	0.00250	-	1.30E-04	-	0.0009
Mesoplodon carlhubbsi	0.00588	7.68E-08	3.06E-04	5.38E-07	0.0021
M. densirostris	0.00588	-	3.06E-04	-	0.0021
M. ginkgodens	0.00588	-	3.06E-04	-	0.0021
Orcinus orca	0.00025	-	1.30E-05	-	0.0001
Peponocephala electra	0.00267	-	1.39E-04	-	0.0010
Phocoenoides dalli	0.05584	-	2.91E-03	-	0.0203

Species	Maximum Average Density (/km²)[1]	Total Number of Exposures for Each Test		Total Number of Exposures for All ARRW Test Series 1 and 2 Flights	
		TTS	Behavioral Disturbance	TTS	Behavioral Disturbance
Physeter macrocephalus	0.00338	-	1.76E-04	-	0.0012
Pseudorca crassidens	0.00087	-	4.53E-05	-	0.0003
Stenella attenuata	0.01132	-	5.89E-04	-	0.0041
S. coeruleoalba	0.13823	-	7.20E-03	-	0.0504
S. longirostris	0.01480	-	7.70E-04	-	0.0054
Steno bredanensis	0.00185	-	9.63E-05	-	0.0007
Tursiops truncatus	0.06836	-	3.56E-03	-	0.0249
Ziphius cavirostris	0.00588	-	3.06E-04	-	0.0021
Arctocephalus townsendi	0.02780	-	1.45E-03	-	0.0101
Callorhinus ursinus	0.02100	-	1.09E-03	-	0.0077
Mirounga angustirostris	0.07600	-	3.96E-03	-	0.0277
Marine Mammal Total		2.08E-07	0.0837	1.46E-06	0.5858
Sea Turtles					
Sea Turtle Guild [2]	0.00430	-	0.0002	-	0.0016

Abbreviations: km² = square kilometer; TTS = Temporary Threshold Shift.
[1] Density Data Source: Navy's Marine Species Density Database (Hanser et al. 2017). Densities represent the maximum average density across all portions of the BOA even though some species do not occur in portions of the BOA. These analyses assume that components would land in an area of highest density for each species and should be considered estimates of maximum effect.
[2] Sea turtles were combined into a "sea turtle guild" in the Hawai`i-Southern California Training and Testing Study Area Marine Species Density Database due to the lack of species-specific occurrence data (Hanser et al. 2017). This sea turtle guild is composed of primarily green and hawksbill turtles as they account for nearly all sightings in the study area; however, in theory, the guild also encompasses leatherback, olive ridley, and loggerhead turtles (Hanser et al. 2017).

Table 4-5. Estimated Number of Marine Mammal and Sea Turtle Exposures Due to Direct Contact from ARRW Components in the BOA.

Species	Estimated Total Number of Exposures per Test Series 1 Test	Estimated Total Number of Exposures per Test Series 2 Test	Estimated Total Number of Exposures for All ARRW Tests
Marine Mammals			
Balaenoptera acutorostrata	1.55E-06	1.09E-06	1.40E-06
B. borealis	1.14E-07	7.93E-08	3.22E-07
B. edeni	1.12E-07	7.75E-08	1.53E-07
B. musculus	9.38E-08	6.43E-08	2.10E-06
B. physalus	8.06E-08	5.55E-08	3.55E-07
Delphinus delphis	1.14E-06	8.39E-07	4.60E-06
Feresa attenuata	6.67E-07	4.92E-07	1.38E-06
Globicephala macrorhynchus	8.63E-07	6.21E-07	9.00E-06
Grampus griseus	2.29E-06	1.60E-06	9.70E-06

Species	Estimated Total Number of Exposures per Test Series 1 Test	Estimated Total Number of Exposures per Test Series 2 Test	Estimated Total Number of Exposures for All ARRW Tests
Indopacetus pacificus	1.03E-06	7.29E-07	1.28E-05
Kogia breviceps	5.44E-07	3.97E-07	8.36E-07
K. sima	1.17E-06	8.64E-07	1.29E-06
Lagenodelphis hosei	3.27E-06	2.41E-06	1.22E-06
Lissodelphis borealis	1.79E-07	1.31E-07	1.94E-05
Megaptera novaeangliae	1.70E-06	1.18E-06	1.06E-06
Mesoplodon carlhubbsi	2.39E-07	7.38E-09	6.03E-08
M. densirostris	1.02E-08	1.71E-07	1.40E-06
M. ginkgodens	5.48E-08	3.95E-08	3.22E-07
Orcinus orca	2.62E-08	1.85E-08	1.53E-07
Peponocephala electra	3.53E-07	2.60E-07	2.10E-06
Phocoenoides dalli	5.94E-08	4.42E-08	3.55E-07
Physeter macrocephalus	7.95E-07	5.53E-07	4.60E-06
Pseudorca crassidens	2.35E-07	1.68E-07	1.38E-06
Stenella attenuata	1.51E-06	1.12E-06	9.00E-06
S. coeruleoalba	1.63E-06	1.20E-06	9.70E-06
S. longirostris	2.14E-06	1.59E-06	1.28E-05
Steno bredanensis	1.40E-07	1.04E-07	8.36E-07
Tursiops truncatus	2.18E-07	1.58E-07	1.29E-06
Ziphius cavirostris	2.08E-07	1.49E-07	1.22E-06
Arctocephalus townsendi	2.96E-08	2.20E-08	1.77E-07
Callorhinus ursinus	2.28E-08	1.69E-08	1.36E-07
Mirounga angustirostris	1.11E-07	8.10E-08	6.59E-07
Total Marine Mammal Exposures	2.26E-05	1.63E-05	7.51E-03
Sea Turtles			
Sea Turtle Guild [2]	5.68E-07	4.29E-07	2.93E-05

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

Vessel strike and increased human activity: Marine mammals in the BOA are not expected to be impacted by human activity and vessel traffic. Only a small number of vessel trips would be required in this area to position onboard sensors. While cetaceans and pinnipeds breath air, must surface to breathe, and are known to bask at the ocean surface, these are highly mobile animals capable of avoiding vessels, and they may already be used to some vessel traffic in the BOA. Given that marine mammal density in this area is low and seasonal, the chances of a marine mammal being impacted by human disturbance or being struck by a vessel is considered extremely low.

Exposure to hazardous chemicals: Hazardous material release in the BOA is not likely to adversely impact marine mammals. The area affected by the dissolution of chemicals would be relatively small because of the size of the ARRW components, and the minimal amount of residual materials they contain. Any chemicals introduced to the water column would be quickly diluted and dispersed, and components would sink to the ocean bottom, where depths in the BOA reach thousands of feet and marine mammals are not likely to occur. Due to the low density and patchy distribution of marine mammals in the BOA, the likelihood of an animal coming into contact with hazardous materials from ARRW test components is extremely low.

Sea Turtles. Overall, sea turtles are not expected to be significantly impacted by any ARRW stressors in the BOA. Any impacts, if realized, would likely be limited to short-term startle reactions, and sea turtles would be expected to return to normal behaviors within minutes. The following sections present the results of analysis of potential impacts of ARRW stressors in the BOA on sea turtles.

Elevated sound level impacts: Elevated SPLs from sonic booms are not expected to impact sea turtles in the BOA as maximum SPLs for sonic booms in the BOA (157 dB re 1 μPa) do not exceed the PTS, TTS, or behavioral disturbance thresholds for sea turtles.

Elevated SPLs from ARRW component splashdown are not expected to impact sea turtles in the BOA. SPLs for component splashdown are not expected to exceed the physical injury (PTS or TTS) thresholds for sea turtles (**Table 4-1**). Based on the best available density data for sea turtles, there is a slight chance that a sea turtles' behavior may be affected by elevated sound pressures in the BOA (**Table 4-4**). The chance of an individual sea turtle being in the area affected by sound pressures high enough to induce behavioral disturbance in the BOA is approximately 1 in 1,000 for the five turtle species combined (**Table 4-4**). Even if an animal were to be exposed to SPLs above the behavioral disturbance threshold, behavioral modifications would be expected to be extremely short lived, and animals are expected to resume normal behavior quickly.

Direct contact: Direct contact from splashdown of vehicle components is not expected to impact sea turtles in the BOA as the calculated chances of a sea turtle being injured are extremely low. The estimated chance of an individual sea turtle exposure to direct contact from falling vehicle components or payloads (ARRW test series 1) in the BOA is 1 in 293,000 (**Table 4-5**) for all ARRW test series 1 and 2 combined. As with cetaceans, it is important to note some of the assumptions of this model that may lead to overestimation of effect. The model is based on the best available density data. Since many density studies of turtles are conducted in nearshore areas, density estimates in deep ocean areas are largely unknown. The model also assumes that the turtles do not move and are at the surface 100 percent of the time.

Vessel strike and increased human activity: Sea turtles in the BOA are not expected to be impacted by human activity and vessel traffic. Only a small number of vessel trips would be required in this area to position onboard sensors. While sea turtles breath air, must surface to breathe, and are known to bask at the ocean surface, these are highly mobile animals capable of avoiding vessels, and they may already be used to some vessel traffic in the BOA. Given that sea turtle density in this area is low and seasonal, the chances of a sea turtle being impacted by human disturbance or being struck by a vessel is considered to be extremely low.

Exposure to hazardous chemicals: Hazardous material release in the BOA is not likely to adversely impact sea turtles. The area affected by the dissolution of chemicals would be relatively small because of the size of the ARRW components and the minimal amount of residual materials they contain. Any chemicals introduced to the water column would be quickly diluted and dispersed and components would sink to the ocean floor, where depths in the BOA reach thousands of feet, and turtles are not likely to occur. Due to the low density and patchy distribution of sea turtles in the BOA, the likelihood of an animal coming into contact with hazardous materials from ARRW components is extremely low.

Birds. Overall, seabirds are not expected to be significantly impacted by any ARRW stressors in the BOA. Any impacts, if realized, would likely be limited to short-term startle reactions, and seabirds would be expected to return to normal behaviors within minutes. The following sections present the results of analysis of potential impacts of ARRW stressors in the BOA on birds.

Elevated sound level impacts: Elevated SPLs from ARRW activities in the BOA are not expected to impact seabirds in the BOA. Maximum SPLs for sonic booms in the BOA (157 dB re 1 μPa) do not exceed the injury threshold for seabirds underwater.

Component splashdown SPLs in-water do not exceed the physical injury threshold for seabirds. In-air splashdown SPLs might exceed the PTS threshold for seabirds out 56 m (185 ft) from spent component splashdown and 32 m (104 ft) from shroud splashdown. Splashdown of all components in the BOA may exceed the behavioral disturbance threshold for these birds across approximately 655 km^2 (253 mi^2). It is not likely that seabirds would be in the area of physical injury; however, some birds might be subject to behavioral disruption. Even if the maximum recorded average at-sea density estimates (across seasons) are used for Newell's shearwaters and Hawaiian petrels (USAF and USASMDC 2019) and assumed for the entire BOA, an estimated three Hawaiian petrels and eleven Newell's shearwaters might be exposed to SPLs above the behavioral disturbance threshold for any given test. Due to the short duration of elevated SPLs for these test flights, any behavioral disturbance is expected to be limited to short-term startle responses and birds would be expected to return to normal behaviors within minutes of any realized disturbance.

Maximum in-air SPLs from sonic booms may exceed the in-air behavioral disruption threshold for seabirds in the BOA also. A conservative estimate indicates in-air SPLs may exceed 93 dB re 20 μPa near the ocean surface up to 79 m (261 ft) from the point/path of maximum sonic boom overpressures in the BOA. If seabirds were in this area, they might exhibit short-duration startle responses; however, no injury or long-term behavioral disturbance would be expected from this short-duration, single event.

Direct contact: Direct contact from splashdown of vehicle components is not expected to impact seabirds in the BOA. Given the small direct contact area of potential effect and the low density and patchy distribution of seabirds in the BOA, it is very unlikely that a seabird would be subject to direct contact from ARRW components. Even if the maximum recorded at-sea density estimates are used for Newell's shearwaters and Hawaiian petrels (USAF and USASMDC 2019) and assumed for the entire BOA, there is only a 1 in 21,500 chance of a Hawaiian petrels being exposed to direct contact from ARRW components and a 1 in 4,200 chance of Newell's shearwaters being exposed for all tests combined. No known density estimates are available for short-tailed albatross or band-rumped storm petrels in the BOA. These birds are likely to have densities and distributions that vary from season to season and in response to ocean conditions and prey availability in the BOA. Given that the total direct contact area for falling ARRW components in the BOA is only 3.9 m^2 (41.9 ft^2) for each test series 2 test, that there would be a limited number of total tests , and the limited distribution and abundance of these birds in the BOA, it is very unlikely that seabirds would be affected by direct contact from falling vehicle components in the BOA.

Vessel strike and increased human activity: Seabirds in the BOA are not expected to be impacted by human activity and vessel traffic. Only a small number of vessel trips would be required in this area to position onboard sensors. While seabirds may rest on the ocean surface, they are very mobile animals which can fly away from approaching vessels and have even been known to follow vessels to feed on prey in the wake of vessels. Given that seabird density in this area is low and seasonal, the chances of a seabird being impacted by human disturbance or being struck by a vessel is considered to be extremely low.

Exposure to hazardous chemicals: Hazardous material release in the BOA is not likely to adversely impact seabirds. The area affected by the dissolution of chemicals would be relatively small because of the size of ARRW components and the minimal amount of residual materials they contain. Any chemicals introduced to the water column would be quickly diluted and dispersed and components would sink to the ocean bottom, where depths in the BOA reach thousands of feet and seabirds and their prey are not likely to occur. Due to the low density and patchy distribution of seabirds in the BOA, the likelihood of an animal coming into contact with hazardous materials from any ARRW test is extremely low.

Fish. Overall, fish are not expected to be significantly impacted by any ARRW stressors in the BOA. Any impacts, if realized, would likely be limited to short-term startle reactions, and fish would be expected to return to normal behaviors within minutes. The following sections present the results of analysis of potential impacts of ARRW stressors in the BOA on fish.

Elevated sound level Impacts: Elevated SPLs from sonic booms are not expected to impact fish in the BOA as maximum SPLs for sonic booms in the BOA (157 dB re 1 μPa) do not exceed the PTS or TTS thresholds for fish and would only exceed the behavioral disruption threshold within 2.2 m (7.3 ft) of maximum sonic boom SPLs in the BOA.

Elevated SPLs from component splashdown are not expected to adversely impact fish in the BOA. Test series 1 vehicle component splashdown has the potential to generate SPLs high enough to induce TTS in fish. However, the area with SPLs above TTS for fish would only be up to 5.6 m (18.5 ft) from splashdown and the area of potential effect would be very small. Due to the low densities and patchy distribution of most fish species in the BOA and the fact that fish occur at some depth below the water surface, it is very unlikely that fish would be injured. Special status fish species are very unlikely to be in this area. Even if a maximum (but likely unrealistically high) density of bigeye thresher sharks is used (USAF and USASMDC 2019), the chances of a shark being in the TTS area of potential effect is extremely low (1 in 1,900). Fish species may be exposed to SPLs high enough to elicit behavioral responses up to 335 m (1,100 ft) from component splashdown. Density data are not available for most fish species in the BOA, but the chance of a fish being exposed to SPLs above the behavioral disturbance threshold is assumed to be very small.

The areas of potential effect detailed above assume that organisms are at the surface of the water. Just as SPLs dissipate with distance from a sound source, sound levels also decrease with water depth. If a fish were to be exposed to elevated SPLs, it is likely that the effects would be temporary behavioral effects due to the short duration (less than 1 second) of potential exposure to elevated noise from a splashdown, and there is no reason to expect that there would be significant or lasting effects or that animal behaviors would not return to normal within minutes of the disruption.

Direct contact: Direct contact from splashdown of vehicle components is not expected to significantly impact fish in the BOA. Given that the total direct contact area for all falling components in the BOA is relatively small for each test series 2 test, that there would be limited total tests and given the low and patchy distribution of fish in the BOA, it is very unlikely that special status fish would be subject to direct contact from ARRW components. If any individual fish of more common species were subject to direct contact from falling components, the number of affected fish would not alter the overall distribution or abundance of these species.

Vessel strike and increased human activity: Fish in the BOA are not expected to be impacted by human activity and vessel traffic. Only a small number of vessel trips would be required in this area to position onboard sensors. Given that fish density in this area is low and seasonal, and that fish occur at some depth below the surface, the chances of fish being impacted by human disturbance or being struck by a vessel is considered to be extremely low.

Exposure to hazardous chemicals: Hazardous material release in the BOA is not likely to adversely impact fish. The area affected by the dissolution of chemicals would be relatively small because of the size of the ARRW components and the minimal amount of residual materials they contain. Any chemicals introduced to the water column would be quickly diluted and dispersed and components would sink to the ocean bottom, where depths in the BOA reach thousands of feet and most fish species are not likely to occur. Due to the low density and patchy distribution of special status fish in the BOA, the likelihood of an animal coming into contact with hazardous materials from the ARRW flight tests is extremely low.

Invertebrates. Overall, invertebrates are not expected to be significantly impacted by any ARRW flight test stressors in the BOA. Special status invertebrates, such as ESA-listed corals and mollusks, are not known to occur in the BOA as adults. For other, generally more common benthic and pelagic invertebrate species (including deep water benthic coral assemblages), the very small areas subject to direct contact, hazardous chemicals, and vessel activity would not alter the overall distribution or abundance of these species even if some individuals were affected.

Direct contact, hazardous chemicals, and cavitation from vessel traffic has the potential to affect individual larval corals or mollusks that may be present as components of drifting plankton. It is possible that a very low number of coral or mollusk larvae would be within the affected volume of water; however, larval densities in BOA waters are likely extremely low and any effects would be on an extremely small fraction of the total larval pool.

4.3 U.S. Army Garrison–Kwajalein Atoll – Illeginni Islet

Vehicle components used during the ARRW test series 1 tests would splashdown somewhere in the BOA. Therefore, potential impacts at Kwajalein Atoll address only the ARRW test series 2 flight tests.

4.3.1 Water Resources

4.3.1.1 Water Resources – No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur and there would be no change to water resources. There would be no site dust suppression, site remediation or use of vehicles at Illeginni Islet. Therefore, no impacts to water resources would occur with implementation of the No Action Alternative.

4.3.1.2 Water Resources – Illeginni Islet

Subsequent to impact, fresh water be used to minimize fugitive dust; waters would not be allowed to flow to the lagoon or ocean and would evaporate in place. In the unlikely event of an accidental release of a hazardous material or petroleum product at the impact site (associated with vehicles used during cleanup and site restoration), emergency response personnel would comply with the

UES KEEP. Due to presence of no surface waters bodies or fresh groundwater, no impacts to water resources would be expected from ARRW test series 2 flight test activities.

4.3.2 Geological Resources

4.3.2.1 Geological Resources – No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur and there would be no change to geological resources. There would be no quarry or backfill operations at Illeginni Islet. Therefore, no impacts to geological resources would occur with implementation of the No Action Alternative.

4.3.2.2 Geological Resources – Illeginni Islet

There would be slight, if any, surface disturbance during the placement of equipment prior to the flight tests. While a temporary crater would be created at impact on Illeginni Islet, the crater would be refilled with ejecta and clean fill materials (from either off island or on island quarry), and the site topography restored. For a deep-water impact, there would be no marine sediment disturbance beyond the settling of the spent stage and shroud as they come to rest on the sea floor after splashing into the ocean. No impacts to geological resources or marine sediments from the ARRW test series 2 flight tests are expected**.**

4.3.3 Cultural Resources

Analysis of potential impacts to cultural resources considers both direct and indirect impacts. Direct impacts may be the result of physically altering, damaging, or destroying all or part of a resource, altering characteristics of the surrounding environment that contribute to the importance of the resource, introducing visual, atmospheric, or audible elements that are out of character for the period the resource represents (thereby altering the setting), or neglecting the resource to the extent that it deteriorates or is destroyed.

4.3.3.1 Cultural Resources – No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur and there would be no change to cultural resources. There would be no site preparation or placement of radars or data collection equipment at Illeginni Islet. Therefore, no impacts to cultural resources would occur with implementation of the No Action Alternative.

4.3.3.2 Cultural Resources – Illeginni Islet

The ARRW test series 2 impacts are proposed to occur on the west end of Illeginni Islet. Archaeological surveys have not found indigenous cultural materials or evidence of subsurface deposits on the Islet. The Cold War-era properties potentially eligible for listing on the RMI NRHP are located in the central and eastern portions of the Islet. Because a land impact would not occur in proximity to known or potential cultural resources on Illeginni Islet, implementation of the

Proposed Action would not result in significant impacts to cultural resources. Personnel involved in the ARRW test series 2 operational activities would be briefed on and would follow UES requirements in handling or avoiding any cultural resources uncovered during operational or monitoring activities.

4.3.4 Land Use

4.3.4.1 Land Use – No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur and there would be no change to current land use. Therefore, no impacts to land use would occur with the No Action Alternative.

4.3.4.2 Land Use – Illeginni Islet

No changes to land use would occur from the ARRW test series 2 flight tests. Illeginni Islet has served as the flight termination site for numerous ballistic and target test flights. The ARRW test series 2 activities are consistent with the RTS mission and are well within the limits of current operations of RTS and USAG-KA. No impacts to land use from the ARRW test series 2 are expected.

4.3.5 Airspace

4.3.5.1 Airspace – No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur; therefore, no impacts to airspace would occur from the No Action Alternative.

4.3.5.2 Airspace – Illeginni Islet

Illeginni Islet is located under international airspace and, therefore, has no formal airspace restrictions. No new special use airspace would be required, expanded, or altered for the ARRW test series 2 flight tests. Local airport operations would not be affected. Commercial and private aircraft would be notified through FAA NOTAMs in advance of the test flight at the request of RTS as part of their routine operations. Flight operations would be conducted in accordance with Western Range and RTS procedures. There would be no impacts to airspace from the ARRW test series 2 flight tests.

4.3.6 Noise

4.3.6.1 Noise – No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur and there would be no change to noise levels at Illeginni Islet. Therefore, no significant impacts would occur from noise with implementation of the No Action Alternative.

4.3.6.2 Noise – Illeginni Islet

Terminal flight of the payload over the RMI would create a sonic boom carpet along its flight path. Because of the vehicle's high-altitude during flight, maximum elevated SPLs from sonic booms beneath the flight path would be 145 dB re 1 µPa (in air) until descent. As the payload nears RTS, the vehicle would fly towards the pre-designated impact site at Illeginni Islet. During vehicle descent, a focused boom would occur over the intended site and the nearby areas of the Atoll.

Similar to the FE-1 vehicle, at the terminal end of the flight path, the sonic boom generated by the approaching ARRW test series 2 vehicle is estimated to peak at less than 180 dB. At the point of impact, the sonic boom footprint would narrow. For payload impact at Illeginni Islet, elevated SPLs due to the sonic boom would be present in the air over land and would also be present in the surrounding waters. The duration for sonic boom overpressures produced by the payload are expected to average 75 ms where SPLs are greater than 140 dB and 270 ms where SPLs are less than 140 dB.

Approximately 1 km^2 (0.4 mi^2) would be exposed to SPLs up to 170 dB. Noise model assumptions for estimating sonic boom overpressures likely lead to conservatively high estimates of sonic boom pressures and, therefore, conservative estimates of the area of potential effect.

Within Kwajalein Atoll, Kwajalein and Roi-Namur islets are the only populated islets under USAG-KA management. There are also Marshallese residents located on Enubirr Islet (southeast of Roi-Namur Islet), Ebeye Islet, Carlos Islet (located a few miles northwest of Kwajalein Islet), and on a few other islets. While meteorological conditions can influence peak SPLs, noise for these areas is estimated to peak at less than 180 dB near the impact. Because the sonic boom footprints at impact normally do not overlap any RMI communities, there are no residents within 29 km (18 mi) of Illeginni Islet, the sonic boom would be audible only once at any nearby locations and last no more than a fraction of a second. Populated areas are located outside the sonic boom footprint and residents at these locations may not hear the noise at all.

Noise levels during pre-test and post-flight activities at the predetermined target site would occur in an unpopulated area without resident receptors. ARRW test series 2 flight test personnel and RTS and USAG-KA personnel also may be required to wear hearing protection in compliance with the Army's Hearing Conservation Program. During the flight test, RTS would verify that no non-mission vessels would be in the area. Depending on a mission vessel's location, on-board personnel may be required to wear hearing protection in compliance with the Army's Hearing Conservation Program.

Range evacuation procedures are implemented during all flight tests, and no residents or personnel are expected to be subjected to significant noise-related impacts. Therefore, no short-term, or long-term, significant impacts would occur from noise as a result of the ARRW test series 2 flight tests.

4.3.7 Infrastructure

4.3.7.1 Infrastructure – No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur; therefore, no impacts to infrastructure would occur from the No Action Alternative.

4.3.7.2 Infrastructure – Illeginni Islet

There would be no changes to infrastructure at Illeginni Islet. The Proposed Action represents activities that are consistent with the mission and well within the limits of current operations of RTS and USAG-KA. No impacts to current infrastructure would occur from the ARRW test series 2 flight tests.

4.3.8 Transportation

4.3.8.1 Transportation – No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur; therefore, no impacts to transportation would occur from the No Action Alternative.

4.3.8.2 Transportation – Illeginni Islet

Transportation services would be unaffected by the ARRW test series 2 flight tests. Public NOTAMs and NTMs would be issued along the flight path, to include Kwajalein Atoll, to protect the safety of aircraft and vessels. The ARRW test series 2 would impact at Illeginni Islet where there is no resident population; there would be no unauthorized vessels or aircraft in the vicinity. Transport of ARRW test series 2 flight test materials, equipment, and personnel to and from USAG-KA and the impact site would occur using existing transportation methods. ARRW test series 2 flight test activities are consistent with the mission and well within the limits of current operations of RTS and USAG-KA. Therefore, there would be no impacts to transportation within RMI, at Kwajalein Atoll or Illeginni Islet.

4.3.9 Public Health and Safety

The public health and safety analysis section address issues related to the health and well-being of military personnel and civilians living on or near USAG-KA; and the environmental health and safety risks to children. Specifically, this section provides information on hazards associated with a singular ARRW test series 2 flight test.

4.3.9.1 Public Health and Safety – No Action Alternative

Under the No Action Alternative, the ARRW test series 2 flight tests would not occur and there would be no change to public health and safety. Therefore, no significant impacts to public health and safety would occur with implementation of the No Action Alternative.

4.3.9.2 Public Health and Safety – Illeginni Islet

There are no resident populations at or in proximity to Illeginni Islet. A NOTAM and an NTM are transmitted to appropriate authorities to clear commercial, private, and non-mission military vessel and aircraft traffic from caution areas and to inform the public of impending missions. The warning messages describe the time, the area affected, and safe alternate routes. The GRMI also is informed in advance of testing and reentry payload missions. A fact sheet describing the project and the environmental controls would be prepared and would be provided at locations on Ebeye and Kwajalein Island. Radar and visual sweeps of hazard areas would be regularly scheduled and conducted prior to launch to clear any non-mission ships and aircraft. No significant impacts to public health and safety are anticipated with the ARRW test series 2 flight test.

4.3.10 Hazardous Materials and Wastes

4.3.10.1 Hazardous Materials and Wastes – No Action Alternative

Under the No Action Alternative, the ARRW test series 2 flight tests would not occur and there would be no change associated with hazardous materials and wastes. Therefore, no significant impacts would occur to hazardous materials and waste with implementation of the No Action Alternative.

4.3.10.2 Hazardous Materials and Wastes – Illeginni Islet

The ARRW test series 2 payload will descend onto Illeginni Islet and break up on impact. As shown in **Table 2-1**, hazardous materials in the payload would be limited to batteries, small electro-explosive devices, and a tungsten alloy. No solid or liquid propellants, depleted uranium, beryllium, or radioactive materials would be carried on the payload. Each battery would be environmentally qualified, including safeguards for containing accidental hazardous battery casing leak or electrical anode or cathode shorting during shipping and handling. Considering the quantities of hazardous materials contained in the batteries and land impact, the battery materials released during payload impact should be of little consequence. All explosive devices would be handled in accordance with DOD 6055.09-STD.

Test activities could produce tungsten and metals in soils from impact of the ARRW test series 2 flight test. Post-test recovery operations at Illeginni Islet require the manual cleanup and removal of any debris, including hazardous materials, followed by filling in of the impact crater using a backhoe or grader. Excavated material would be screened for debris and the crater would be backfilled with material ejected around the rim of the crater and clean materials as required. Following removal of all experiment items and any remaining debris from the target site, all waste materials would be returned to Kwajalein Island for proper disposal in the United States. Although unlikely, removal of surface floating debris in the lagoon and ocean reef flats, within 150 to 300 m (500 to 1,000 ft) of the shoreline, would be conducted similarly to land operations when tide conditions and water depth permit.

Based on soil and groundwater sampling results (conducted after the Navy FE-1 rocket tests), as identified in **Section 3.5.10**, bench studies conducted for the assessment of geochemical parameters and their influence on tungsten mobility in soils (Bednar et al. 2008) and peer reviews by RMIEPA in 2017, determined that the long-term known impact or potential risk of tungsten at Illeginni Islet is not conclusively identified. The bench study and mobilization model results do indicate that levels of tungsten in the soil and ground water at Illeginni Islet are below the USEPA Residential RSLs (63 mg/kg and 0.016 mg/L, respectively) (LLNL 2017), and will remain so for 25 years, the period for which the model was run. Initial sampling of tungsten and other alloy metals in soil at Illeginni Islet was conducted after the FE-1 test flight in November 2017, and the results showed an average of 3.0 mg/kg (range of 0.7 to 9.0 mg/kg), well below the Residential RSL. Additional soil sampling conducted at the site in February 2018 showed an average tungsten level of 2.3 mg/kg (range of 0.2 to 10.4 mg/kg). The measured post-event tungsten concentrations were all below the Residential RSL of 63 mg/kg and well below the Commercial RSL of 930 mg/kg. The measured post-event tungsten concentrations were also in reasonable agreement with LLNL’s 2017 estimates of post-event sediment tungsten concentration of 6.5 mg/kg.

The UES has restoration criteria that trigger when remediation is required. Because the reasonably foreseeable land use at Illeginni Islet is as a test range, the commercial screening criteria is used as the trigger for a risk assessment. If the land use would change, the site would be evaluated under the UES Restoration requirements to determine if the new land use required institutional controls or remediation.

Water samples collected in the FE-1 site shortly after the event had tungsten concentrations of 0.65 mg/L (range 0.64 to 0.67 mg/L). These values are above the USEPA RSL for tap water of 0.016 mg/L. In September 2018 seven groundwater monitoring wells were installed on Illeginni Islet, five of them at the FE-1 site. Tungsten was detected in seven of the nine groundwater samples collected from the Illeginni wells. Detected concentrations ranged from 0.055 mg/L to 1.2 mg/L. All detected concentrations exceed the USEPA residential tap water screening level of 0.016 ug/L, including the sample from the background well (0.23 mg/L). Tungsten at the background well may be either naturally elevated or present due to past actions on Illeginni Islet.

The main reason for installing the groundwater monitoring wells was to determine if the groundwater at Illeginni Islet was a viable source of potable water. Section 3-2.4.2 of the UES (USASMDC/ARSTRAT 2018) defines groundwater quality classes based on total dissolved solids (TDS) content in mg/L, which is equivalent to parts per million (ppm) by mass. The UES-defined classes are as follows:

- Class I: desired source of potable water; TDS not exceeding 500 mg/L (0.5 parts per trillion [ppt]);
- Class II: potential source of potable water; TDS 500 mg/L to 1,000 mg/L (0.5 to 1.0 ppt);
- Class II: other uses; TDS 1,000 mg/L to 10,000 mg/L (1.0 to 10 ppt);

- Class III: limited use, non-potable; TDS exceeding 10,000 mg/L (10 ppt).

None of the samples meet the criteria for Class I desired source of potable water or Class II potential source of potable water, and therefore the groundwater at Illeginni Islet is not considered a viable source of potable water.

Although the groundwater at Illeginni Islet shows tungsten levels above the RSL, the groundwater is not potable under the UES standards. With the reasonably foreseeable land use at Illeginni Islet as a test range and with the groundwater not being potable, further risk-based analysis is not planned at this time. If the land use would change, the site would be evaluated under the UES Restoration requirements to determine if the new land use required institutional controls or remediation. Additional sampling of the groundwater for tungsten would be conducted following the ARRW test series 2 flight test.

Sampling and analyses of soils and groundwater are planned to be conducted after each ARRW test series 2 flight test. If analyses of ARRW test series 2 post-flight test soil samples indicated tungsten levels above Residential RSLs, remedial techniques (such as phytoremediation, using plants to draw up metals from the soil), would be considered and suggested for consideration to the USEPA. However, based upon sampling results associated with past test events of similar payload systems (and metal components), no significant impacts to public health and safety are anticipated with the ARRW test series 2 flight tests.

In the event of an accidental discharge (fuels, oils, etc.) during test flight operations or post-test cleanup activities, ground personnel would comply with the UES KEEP controlling the spill site and cleanup. No short-term or long-term impacts from materials associated with either the ARRW test series 2 flight tests or accidental spills are anticipated.

4.3.11 Socioeconomics

4.3.11.1 Socioeconomics – No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur; therefore, no impacts to socioeconomics would occur from the No Action Alternative.

4.3.11.2 Socioeconomics – Illeginni Islet

Use of USAG-KA by the U.S. Army is maintained under the MUORA and Compact of Free Association, with lease payments made to the Marshallese landowners. The current lease is valid through 2066 with an additional option through 2086 (MUORA 2003). Personnel conducting the ARRW test series 2 flight tests would reside only temporarily at USAG-KA, and the ARRW test series 2 flight tests would not employ any Marshallese citizens or contribute to the local Marshallese economy. There is no resident population at Illeginni Islet. Therefore, there would be no impacts to socioeconomics from the ARRW test series 2 flight tests.

4.3.12 Environmental Justice

4.3.12.1 Environmental Justice – No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur; therefore, no environmental justice impacts would occur from the No Action Alternative.

4.3.12.2 Environmental Justice – Illeginni Islet

Illeginni Islet does not include any population centers; there is no resident population located at Illeginni Islet. Therefore, there would be no disproportionate impacts from the ARRW test series 2 flight tests to minority populations and low-income populations as defined under EO 12898.

4.3.13 Visual Resources

4.3.13.1 Visual Resources – No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur; therefore, no impacts to visual resources would occur from the No Action Alternative.

4.3.13.2 Visual Resources – Illeginni Islet

There would be no changes to and, therefore, no impacts to the visual aesthetics at USAG-KA Illeginni Islet from the ARRW test series 2 flight tests.

4.3.14 Air Quality, Greenhouse Gases, and Climate Change

4.3.14.1 Air Quality – No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur; therefore, no impacts to air quality would occur from the No Action Alternative.

4.3.14.2 Air Quality – Illeginni Islet

The ARRW test series 2 payload would not emit HAPs during impact at Illeginni Islet and no major stationary emission sources would be used during the ARRW test series 2 flight tests. Fugitive dust from a land impact would be temporary and quickly dispersed by trade winds. Prior to debris recovery at Illeginni Islet, the area would be wetted with freshwater to minimize fugitive dust.

Although global sea level is documented to be rising based on climate change and the islands within USAG-KA are of low elevations, the subtle effects of rising sea level and climate change would not be affected by the ARRW test series 2 flight tests after signing of the FONSI, if approved. The ARRW test series 2 flight tests would not affect climate change. No impacts to air quality or GHGs would be expected from the ARRW test series 2 flight tests.

4.3.15 Biological Resources (USAG-KA)

Potential environmental consequences of the Proposed Action on biological resources are evaluated based on the best available information about species distributions and in the context of the regulatory setting discussed in **Chapter 3.0**.

4.3.15.1 Biological Resources – No Action Alternative

Under the No Action Alternative, the Proposed Action would not occur and there would be no change to biological resources. Therefore, no significant impacts to biological resources would occur with implementation of the No Action Alternative.

4.3.15.2 Biological Resources at Illeginni Islet – Preferred Action

The Proposed Action is evaluated for the potential impacts on biological resources at Illeginni Islet. Potential impacts of the Proposed Action in this area include exposure to ARRW test series 2 stressors including elevated SPLs, direct contact from payload components or impact debris, disturbance from human activity and equipment operation, and exposure to hazardous chemicals. These stressors would only occur in the Illeginni Islet ROI during the ARRW test series 2 flight tests.

4.3.15.2.1 Potential Stressors at Illeginni Islet

The following stressors have the potential to impact biological resources at Illeginni Islet:

Exposure to Elevated Sound Pressure Levels

The Proposed Action has the potential to result in elevated SPLs both in-air and underwater near Illeginni Islet. The primary elements of the Proposed Action that would result in elevated SPLs near Illeginni Islet are: (1) sonic booms and (2) terminal impact of the ARRW test series 2 payload. General characteristics of sound and SPL units as well as effect thresholds for species are discussed in **Section 4.1.15.3**.

Sonic Booms. At the terminal end of the flight path, a sonic boom would be generated by the approaching payload. Estimates of peak SPLs for the ARRW test series 2 payload sonic boom are not available. Estimates of SPLs for the larger FE-1 payload which impacted on Illeginni are available (U.S. Navy and USASMDC 2017). Here the FE-1 payload sonic boom peak overpressure estimates were used as a conservative approach for ARRW test series 2 flight test. Sonic boom intensities for the ARRW test series 2 payload are expected to peak at less than 180 dB near impact. At the point of impact, the sonic boom footprint is expected to narrow to about 46 km (25 nm) at this peak pressure. For payload impact at Illeginni Islet, elevated SPLs due to the sonic boom would be present in the air over land and would also be present in the surrounding waters. Approximately 52 km^2 (20 mi^2) of ocean surface would be exposed to SPLs up to 160 dB (in-water) and 304 km^2 (117 mi^2) to SPLs up to 150 dB. In-air at the ocean surface, sonic boom SPLs would not exceed 154 dB re 20 µPa near payload impact at Illeginni Islet. The duration for sonic boom overpressures produced by the ARRW test series 2 payload are unknown but are expected to be on the order of a second long.

Payload Impact. Impact of ARRW test series 2 payload at the terminal end of the flight would also result in elevated in-air and/or underwater sound levels. Maximum SPL estimates from previously evaluated payload impacts at Illeginni Islet were 140 dB at 18 m (59 ft; U.S. Navy and USASMDC 2017). Since these previously analyzed payloads were larger than the ARRW test series 2 payload, these levels were used as a maximum bounding case for ARRW test series 2. Using the spherical spreading model, the dB source level is estimated to be 165 dB in-air and an estimated 191 dB in-water.

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

Effect Thresholds for Consultation Species. The general consequences of elevated sound pressure on terrestrial and marine wildlife species as well as acoustic effect thresholds are discussed in **Section 4.1.15.3** and in the ARRW BA (USAF and USASMDC 2019).

Methods for Estimating Elevated Sound Level Effects. Methods for estimating the effects of elevated SPLs on terrestrial and marine wildlife are discussed in **Section 4.1.15.3** and **4.2.14.2**. The only difference in calculations is that a conical (spreading coefficient = 15) rather than spherical spreading model was used to determine the range to threshold because of the shallow water near Illeginni Islet. Marine mammals are not expected to be in the shallow waters near Illeginni Islet that may be exposed to elevated SPLs. Density data for sea turtles, fish, and birds near Illeginni Islet are largely lacking. Density data for some species were extrapolated from studies of other Central Pacific Islands such as Guam and Hawai`i as discussed in the corresponding consequences sections below.

Direct Contact

During each of the ARRW test series 2 test flights, the ARRW test series 2 payload would impact on Illeginni Islet. For this terrestrial impact on Illeginni Islet, the payload would likely form a crater including ejecta spreading out from the crater. The designated impact zone is an area approximately 290 m (950 ft) by 137 m (450 ft) on the northwest end of Illeginni Islet (**Figure 4-1**), as limited by available land mass. The footprint of a payload impact on land would be roughly elliptical, but its size would depend on the precise speed of the payload and its altitude. Exact speed, altitude, and size information are not available for an ARRW test series 2 terminal payload impact. Since the ARRW test series 2 payload is smaller in size than payloads that have previously been analyzed for impact at Illeginni, cratering estimates for MMIII RVs and the FE-1 payload are used as a maximum bounding case for potential ARRW test series 2 impacts. Based on estimates of the ejecta field and cratering for MMIII RVs, ARRW test series 2 is expected to produce an ejecta field from crater formation at impact that would cover a semicircular area (approximately 120 degrees [º]) 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). Craters from ARRW test series 2 payloads are expected to be smaller than MMIII RV craters which have been documented at 6 to 9 m (20 to 30 ft) in diameter and 2 to 3 m (7 to 10 ft) deep.

Figure 4-1. Representative Maximum Direct Contact Areas of Potential Effect for a Shoreline Payload Impact at Illeginni Islet, Kwajalein Atoll.

The ARRW test series 2 tests payloads are planned to impact on Illeginni Islet within the designated impact zone (**Figure 4-1**). While not planned, a shoreline impact has the potential to affect sea turtle nesting habitat. It is possible that a payload impact on the shoreline at Illeginni would affect the nearshore marine environment through ejecta from a crater and/or falling fragments. Direct contact affects in the nearshore marine environment are expected to be within a semicircular area no more than 91 m (300 ft) from the shoreline (**Figure 4-1**). 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).

Methods for Estimating Direct Contact Effects. 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 impact at least some of the fish, coral and mollusk species on the adjacent reef. Attempts would be made to avoid payload impact near these sensitive shoreline areas; however, for the ARRW EA/OEA and in the ARRW BA (USAF and USASMDC 2019) the worst-case scenario was analyzed to elucidate the maximum effects of the Proposed Action.

On both sides of Illeginni Islet, the area potentially affected by shock waves is encompassed within the area potentially affected by debris fall (**Figure 4-1**). Since these areas overlap and since harmed individuals should be counted only once in the effects of the Proposed Action, the affected habitat area with the largest estimated take, the debris fall/ejecta area, was selected as the worst-case scenario. Although the exact shape of the area of potential effect 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; **Figure 4-1**). 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 square yards [yd^2]). 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 area of potential effect (**Figure 4-1**) is considered potentially viable habitat for consultation fish, coral, and mollusks (NMFS-PIRO 2017c). Similarly, approximately 75% or 9,756 m^2 (11,668 yd^2) of the ocean-side area of potential effect (**Figure 4-1**) is considered potentially viable habitat for consultation fish, coral, and mollusk species (NMFS-PIRO 2017c).

Non-larval forms of 43 coral species, 6 mollusk species, and at least 45 fish species are known to occur in the area that has the potential to be subject to direct contact from ARRW test series 2 terminal impact at Illeginni (**Section 3.5.15.2**, NMFS-PIRO 2017a). In 2017, NMFS-PIRO completed reports with density estimates for consultation species based on 2014 assessments of the reefs adjacent to the impact area at Illeginni Islet (NMFS-PIRO 2017a and 2017b). The areas surveyed for this assessment encompassed all of the reef habitat in the area of potential effect on the lagoon side and 99% of the reef area on the ocean side (NMFS-PIRO 2017a and 2017b). Based on coverage area of this assessment, these data are considered the best available information for coral and mollusk species presence and density in the area of potential effect (see **Table 4-6)**. The number of adult coral and mollusks potentially affected by the Proposed Action was calculated as the estimated area of suitable habitat in the area of potential effect times the 99% upper confidence limits (UCL) of the bootstrap mean density values (see **Table 4-6**).

The humphead wrasse was not observed during the 2014 surveys for the most recent assessment of consultation organisms at Illeginni Islet (NMFS-PIRO 2017a); however, this species has been recorded in both ocean-side and lagoon-side habitats adjacent to the impact area in other surveys. Based on methods which were previously used for impact analyses at Illeginni Islet, an estimated 8 adults may occur within the entire ocean-side area of potential effect, and 0 to 100 juveniles may occur within the entire lagoon-side area of potential effect (USAF and USASMDC 2019, NMFS-PIRO 2014).

Vessel Strike

For ARRW test series 2 flight tests, pre-test activities would include vessel traffic to and from Illeginni Islet. Prior to the test flight, radars may be placed on Illeginni Islet and would be transported aboard ocean-going vessels. Sensor rafts may also be deployed near the impact site from a landing craft utility (LCU) vessel including self-stationing rafts, some potentially with hydrophones. Post-test recovery efforts would also result in increased vessel traffic to the payload impact site. There would be several pre-test vessel round-trips to and from Illeginni Islet as well as potential raft-borne sensor deployment using an LCU. Vessels would 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. Debris would only be recovered in waters up to approximately 55 m (180 ft) deep. Post-test vessel traffic would likely include several vessel round-trips to and from Illeginni Islet. Any deployed sensor rafts would also be recovered by an LCU vessel. Vessel traffic to and from Illeginni Islet may be increased for a period of 10 weeks for each test.

Organisms have the potential to be affected by vessel strike primarily by being at the surface when a vessel travels through an area. Organisms at the surface are at risk of being struck by the vessel or their propellers. Benthic organisms have the potential of being struck when a vessel drops anchor or if a vessel runs aground.

Disturbance from Human Activity and Equipment Operation

Elevated levels of human activity are expected at Illeginni Islet, before and after, each test. During this period, several vessel round-trips are likely. Helicopters and vessels would be used to transport equipment and personnel to Illeginni Islet. The Proposed Action is expected to involve as many as two dozen personnel on Illeginni. Activities associated with pre- and post-flight operations near the Illeginni shoreline, which could impact sea turtles, fish, corals, or mollusks, include noise, physical contact, turbidity changes, or habitat disturbance. In the event of an impact on the Illeginni shoreline, post-flight operations would be conducted similarly to terrestrial operations, when tide conditions and water depth on the adjacent nearshore reef permit. A backhoe would be used to excavate the crater, excavated material would be screened for debris, and the crater would usually be backfilled with substrate that had been ejected around the wall of the crater. Should any components or debris impact areas of sensitive biological resources such as the coral reef, USFWS and NMFS would be contacted to provide guidance and/or assistance in recovery operations to minimize impacts to resources.

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

In the event that recovery operations must take place in the shallow water marine environments at Illeginni Islet, physical contact by humans (e.g., handling, walking on, and kicking with fins) may injure corals and is likely to disturb reef-associated fish and mollusks. Contact by equipment may also injure or kill corals and mollusks and may injure or kill reef-associated fish. The extent of this potential impact would be restricted to the vicinity of the payload land impact site and the access corridor between this site and the adjacent reef.

Exposure to Hazardous Chemicals

The payload would impact at Illeginni Islet. Following the impact of the payload, fragmentation of the payload would disperse any of the residual onboard hazardous materials (**Table 2-1**) such as battery acids, residual explosives, and heavy metals, around the impact point. Onboard the payload there would be batteries and radio frequency transmitters. The batteries carried onboard the payload would be discharged by the time the vehicle impacts on land at Illeginni Islet; however, a small quantity of electrolyte material (on the order of a couple of ounces) may still enter the terrestrial environment. The payload also carries approximately 79 kg (175 lb) of tungsten alloy which would enter the terrestrial and possible marine environments upon payload impact. The payload structure itself contains heavy metals including aluminum, titanium, steel, magnesium, tungsten, and metal alloys.

Considering the small quantities of hazardous materials contained in the batteries, the planned land impact, and the dilution and mixing capabilities of the ocean and lagoon waters, the battery materials released during payload impact should be of little consequence to any cetaceans, fish, or sea turtles in the area. Any visible battery fragments in the lagoon, in other shallow waters, or on Illeginni Islet would be removed during recovery and cleanup. While every attempt would be made to clean up all visible metal and other fragments, it is possible and likely that some fragments would be too small to be recovered or may be buried by the force of impact. Therefore, it should be considered that a small but unknown amount of these heavy metals or other substances may remain in the terrestrial or marine environments at Illeginni Islet.

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

Small radars powered by car batteries may be placed in the payload impact area and would be destroyed by the impact. While the debris from these radars would expect to be recovered, acids and heavy metals may be introduced into the terrestrial environment. Only trace amounts of hazardous chemicals are expected to remain in terrestrial areas. If any hazardous chemicals enter the marine environment, they are expected to dilute and dispersed quickly by currents and wave action.

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

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

- Vessel and equipment operations would not involve any intentional discharges of fuel, toxic wastes, or plastics and other solid wastes that could harm terrestrial or marine life.

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

4.3.15.2.2 Consequences for Biological Resources at Illeginni Islet

Terrestrial Vegetation at Illeginni Islet

Terrestrial vegetation in the payload impact zone at Illeginni is vegetation of previously disturbed habitat and is predominantly managed vegetation. Therefore, no adverse impacts to terrestrial vegetation are expected.

Terrestrial Wildlife at Illeginni Islet

Sea Turtles and Sea Turtle Nests. Overall, sea turtles on land and sea turtle nests are not expected to be impacted by ARRW test series 2 activities on Illeginni Islet.

Only green sea turtles and hawksbill turtles have been observed near Kwajalein Atoll islets. These two species are known to nest or haul out on some Kwajalein Atoll Islets. If a sea turtle or sea turtle nest were struck by debris or ejecta from payload impact, a sea turtle could be killed or injured, or sea turtle eggs could be damaged or destroyed. Turtles also have the potential to be subject to behavioral disruption from elevated sound levels, human disturbance, or equipment operation, significant enough to preclude females from haul-out and nesting. Any debris and ejecta have the potential to include hazardous chemicals including heavy metals. If these chemicals were introduced into sea turtle nesting habitat, they have the potential to dissuade females from nesting, harm sea turtle eggs, or affect the health of sea turtle hatchlings.

Suitable sea turtle haulout and nesting habitat exists on the northwestern and eastern beaches of Illeginni Islet (**Figure 4-1**). In a 2008 survey of Illeginni Islet, suitable nesting habitat for sea turtles was identified, consisting or relatively open sandy beaches and seaward margins of herbaceous strand above tidal influence (**Figure 4-1**; USFWS 2011a). These areas were thoroughly surveyed on foot for nesting pits and tracks, but none were found. These nesting and haulout habitats were reevaluated during the 2010 inventory (USFWS and NMFS 2012) and were determined to still be suitable habitat. However, the last known sea turtle nest pits on Illeginni were recorded in 1996 on the northern tip of the islet. No sea turtle nests or nesting activity have been observed on Illeginni in over 20 years. While green and hawksbill turtles are known to use the nearshore waters of Illeginni Islet it is unlikely that sea turtles will haul out or nest on Illeginni Islet.

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

Birds. Overall, birds on Illeginni Islet are not expected to be significantly impacted by ARRW test series 2 activities at Illeginni Islet. Any impacts are likely to be limited to short-term startle reactions, and birds would be expected to return to normal behaviors after the disturbance has ended. The following sections present the results of analysis of potential impacts of ARRW test series 2 stressors at Illeginni Islet on birds.

Elevated sound level impacts: A payload impact on Illeginni has the potential to impact nesting, roosting, and foraging bird species. If birds were exposed to elevated sound pressures above PTS threshold levels, physical injury or even death could result. Birds are able to recover from hearing damage better than many other species, and most physical injury would likely be temporary; however, very loud sounds may cause permanent damage.

Sonic boom overpressures generated by the approaching payload (maximum 154 dB re 20 µPa) would exceed the in-air PTS threshold for birds (140 dB re 20 µPa for blast noise), but only out 5 m (16 ft) from the payload flight path. This PTS area of potential effect is smaller than the potential impact area on Illeginni Islet, and birds are unlikely to occur there. It is likely that birds would be exposed to SPLs lower than the PTS threshold but high enough to cause behavioral disturbance out 1,122 m (3,681 ft) from maximum sonic boom SPLs. While birds might be temporarily startled by these sounds, any behavioral or physiological response is likely to be very brief as the duration of the elevated SPLs from sonic booms are on the order of a second. No adverse impacts to birds on or near Illeginni Islet are expected due to elevated SPLs from sonic booms.

Elevated SPLs from payload impact would only exceed the PTS threshold for birds out to 18 m (59 ft) from the point of impact. The impact area is composed primarily of previously disturbed habitat and mitigation measures to deter bird from nesting and roosting in the impact area would be employed such as visual deterrents (e.g., scarecrows, Mylar flags, helium-filled balloons, or strobe lights). Therefore, birds are not expected to be in this disturbed portion of the Islet that is the impact zone. Birds are expected to be roosting, foraging, or nesting (depending on the season) in the area surrounding the impact zone that may be subject to SPL exceeding bird's behavioral disturbance threshold. While birds are likely to be exposed to SPLs high enough to elicit behavioral response, any response to this short duration sound is likely to be limited to temporary startle responses. Bird behavior is expected to return to normal within minutes of impact, and no lasting behavioral or physiological responses are expected. Birds may be more sensitive to elevated SPL disturbance at certain nesting cycle stages (U.S. Navy 2015). There is evidence that elevated noise levels may be more likely to cause nest abandonment during the incubation stage than during brooding of chicks (U.S. Navy 2015). In general, the nesting season for seabirds and shorebirds at Illeginni and other USAG-KA islets begins in October and continues through April. In 2011, a USFWS and U.S. Geological Survey team (Foster and Work 2011) evaluated the response of birds to the Advanced Hypersonic Weapon test impact at the helipad on Illeginni Islet with pre- and post-test site visits. Post-test visits revealed that black-naped terns were actively feeding chicks post-test at nests approximately 65 and 100 m (213 and 328 ft) from the impact site (Foster and Work 2011). White terns were also observed roosting about 140 m (459 ft) from the impact site post-test (Foster and Work 2011). Based on these observations, short-duration elevated SPLs from ARRW test series 2 activities are not expected to cause birds to abandon nests, even during nesting season. Elevated SPLs from payload impact are not expected to adversely impact seabirds at and near Illeginni Islet.

<u>Direct Contact and Human Disturbance</u>: Due to the potential for impacts to black-naped terns nesting in the payload impact area on Illeginni Islet, the USAF had developed several avoidance and minimization measures based on recommendations from the USFWS (**Table 4-8, Appendix A**). The impact area is composed primarily of previously disturbed habitat, and no more than 12 black-naped terns (4 adults and 8 eggs or chicks) would be expected to be in the impact area during daylight hours (**Appendix A**: USFWS Correspondence, Dated 18 March 2019). Mitigation measures to deter birds from nesting and roosting in the impact area would be employed such as visual deterrents (e.g., scarecrows, Mylar flags, helium-filled balloons, or strobe lights). The impact area would be searched for nests, including eggs and chicks, prior to pre-flight activities and prior to test fights. If black-naped tern nests are found in the payload impact area, nests would be covered with an A-frame structure to protect eggs, chicks, and adults from debris and to serve as a warning to project personnel to avoid the nest area. With these mitigation measures in place, no adverse effects to black-naped terns are expected.

Marine Vegetation at Illeginni Islet

Overall, marine vegetation, including seagrass, is not expected to be significantly impacted by any ARRW test series 2 stressors at Illeginni Islet. Most macroalgae species found at Illeginni Islet are common and likely to be found throughout Kwajalein Atoll. While seagrass beds are important habitats for green sea turtles and are relatively limited in distribution, seagrass is only known to occur in and near Illeginni Harbor in the ROI. Vessel traffic would occur in Illeginni harbor; however, no activities are expected that would physically alter benthic habitats or impact seagrass in the ROI.

Marine Wildlife at Illeginni Islet

Marine Mammals. Overall, marine mammals are not expected to be significantly impacted by any ARRW stressors at Illeginni Islet. Any impacts, if realized, would likely be limited to short-term startle reactions, and marine mammals would be expected to return to normal behaviors within minutes. Marine mammals do not occur in the shallow water habitats near Illeginni Islet that have the potential to be subject to direct contact or hazardous chemical effects. The following sections present the results of analysis of potential impacts of elevated sound levels and vessel traffic in offshore waters of USAG-KA on marine mammals.

Elevated sound level impacts: Maximum sonic boom SPLs and SPLs generated by payload impact do not exceed the PTS or TTS thresholds for any marine mammals. There is a potential for behavioral disruption due to sonic boom SPLs in cetaceans near the payload impact point; however, only an area within 22 m (71 ft) of the point/path of maximum sonic boom SPLs would be subject to SPLs ≥160 dB. Marine mammals are not likely to be in this area and any realized behavioral disturbance would likely be limited to startle responses with marine mammals returning to normal behaviors within minutes. Marine mammals are not expected to be in the shallow water area that would be subject to payload impact SPLs above the behavioral disturbance threshold (only out 117 m or 383 ft from impact).

Vessel strike and disturbance from human activity: A small number of vessel trips would be required to support pre-flight activities and equipment placement and post-flight cleanup activities on and near Illeginni Islet. Cetaceans present in the vicinity of Illeginni Islet are not likely to be impacted by vessel strike or human activity. While cetaceans breath air, must surface to breathe, and are known to bask at the ocean surface, these are highly mobile animals capable of avoiding vessels, and they may already be used to some vessel traffic in Kwajalein Atoll. To help avoid any possible impacts, vessel operators would also watch for and avoid cetaceans by adjusting their speed.

Sea Turtles. Overall, sea turtles are not expected to be significantly impacted by any ARRW test series 2 stressors in the water near Illeginni Islet. Any impacts, if realized, would likely be limited to short-term startle reactions, and sea turtles would be expected to return to normal behaviors within minutes. Sea turtles are not expected to be in the in the very shallow water habitats near Illeginni Islet that have the potential to be subject to direct contact or hazardous chemical effects from payload impact. The following sections present the results of analysis of potential impacts of elevated sound levels and vessel traffic in offshore waters of USAG-KA on sea turtles.

Elevated sound level impacts: Elevated SPLs from sonic booms and payload impact do not exceed the physical injury thresholds (PTS or TTS) for sea turtles near Illeginni Islet. Sea turtles might be exposed to sonic boom SPLs above the behavioral disturbance threshold over an area of 52 km^2 (20 mi^2). Payload impact SPLs above 160 dB may extend out 117 m (384 ft) from payload impact. Using density estimates from nearshore areas of other remote Pacific Islands

(**Table 4-4**; USAF and USASMDC 2019), an estimated 20 green turtles and 7 hawksbill turtles might be exposed per test to SPLs high enough to cause behavioral disturbance from both sonic booms and payload impact in USAG-KA waters (USAF and USASMDC 2019). Turtle densities are likely to vary greatly among Pacific Islands; however, these were the best available data and were used to estimate the number of sea turtles that might be exposed to elevated SPLs near Illeginni. It is important to note that although the best available nearshore density data were used, the density and distribution of sea turtles near Illeginni Islet remains unknown. Based on assumptions used in these analysis (USAF and USASMDC 2019), the estimates for the chances of elevated sound levels affecting individual sea turtles are likely overestimates. However, these estimates do provide a conservative estimate of effects. While there is a chance a sea turtle would be exposed, this is a single event with elevated SPLs lasting less than a second. Any impacts would likely be limited to short-term startle reactions, and sea turtles would be expected to return to normal behaviors within minutes.

<u>Vessel strike and disturbance from human activity</u>: A small number of vessel trips would be required to support pre-flight activities and equipment placement and post-flight cleanup activities on and near Illeginni Islet. Sea turtles present in the vicinity of Illeginni Islet are not likely to be impacted by vessel strike or human activity. While sea turtles breath air, must surface to breathe, and are known to bask at the ocean surface, these are highly mobile animals capable of avoiding vessels, and they may already be used to some vessel traffic in Kwajalein Atoll. To help avoid any possible impacts, vessel operators would also watch for and avoid sea turtles by adjusting their speed. Disturbance from human activity is not expected to significantly alter the natural behavioral patterns of sea turtles near Illeginni Islet.

<u>*Fish*</u>. Overall, scalloped hammerhead sharks, manta rays, and most other fish species are not expected to be significantly impacted by any ARRW test series 2 stressors at Illeginni Islet. Considering the worst-case scenario of a shoreline payload impact, the humphead wrasse may be impacted by direct contact from debris or ejecta and/or disturbance from human activity. The following sections present the results of analysis of potential impacts of ARRW test series 2 stressors on fish near Illeginni Islet.

<u>Elevated sound level impacts</u>: Elevated SPLs from sonic booms near Illeginni islet do not exceed the physical injury thresholds (PTS or TTS) for fish. Sonic boom overpressures would exceed the behavioral disturbance threshold for fish over an area up to 304 km^2 (117 mi^2). The maximum radial distance at which fish might be subject to injury from elevated SPLs generated by payload impact is only 2.2 m (7.2 ft) from payload impact and 541 m (1,775 ft) for behavioral disturbance. Adult fish are not expected to be within 2.2 m (7.2 ft) of payload impact on Illeginni Islet as a terrestrial impact is planned. There are no known reliable density estimates for consultation fish species in the shallow waters near Kwajalein Atoll. Even fish species known to occur near Illeginni Islet likely have very low densities in these areas with patchy distributions. Reef manta ray density estimates are available for nearshore waters in Guam and range from 0.01 to 0.03 fish per km^2

(Martin et al. 2016). Even if an estimate of reef manta ray density on the high end of estimated density (0.03 per km^2) is used, only nine reef manta rays have the potential to be exposed to SPLs above the behavioral disturbance threshold. Some adult or juvenile humphead wrasse or other reef-associated fish species may be exposed to behavioral disturbance from elevated SPLs as well. If fish are exposed to SPLs above the behavioral disturbance threshold, any behavioral disturbance is expected to be limited to short-term startle response. Elevated SPLs from payload impact are not expected to adversely impact fish near Illeginni Islet.

Direct contact: The impact zone for the ARRW test series 2 payload is a terrestrial area on Illeginni Islet. While marine habitats are not targeted during the ARRW test series 2 tests, a payload land strike on or near the shoreline could result in ejecta/debris fall and shock wave effects, which have the potential to impact at least some fish species on the adjacent reef. The anticipated worst-case scenario of a payload land impact at Illeginni Islet is considered to be a shoreline strike, which might result in debris fall and shock wave effects within an area that would extend outward from the point of strike up to 91 m (300 ft) as described in methods above (**Figure 4-1**). Fish mortality or injury could occur from impact by ejecta/debris fall within this area. Several fish species are known to occur in this area of potential effect and may be impacted by direct contact from debris or ejecta (**Section 3.5.15.2**). These fish species occur on reefs throughout Kwajalein Atoll. Given that a shoreline strike is unlikely and that the numbers of fish species near Illeginni Islet is likely a small fraction of the populations of these fish in Kwajalein Atoll, most fish species are not likely to be significantly impacted by direct contact.

One consultation fish species, the humphead wrasse, is likely to be impacted by direct contact in the event of a shoreline payload impact. Based on the methods described above and analyses in the ARRW BA (USAF and USASMDC 2019), an estimated maximum of 100 juvenile humphead wrasses may be found in lagoon-side and 8 adults in the ocean-side direct contact area of potential effect. The USAF has concluded that these activities may adversely affect the humphead wrasse (USAF and USASMDC 2019) and initiated consultation with NMFS. In their Final Biological Opinion (NMFS 2019; **Appendix C**), NMFS concluded that a total of up to 108 individuals could be affected by direct contact, ejecta, and/or shock waves from an ARRW test series 2 payload impact near the Illeginni shoreline. The NMFS also concluded that the potential loss of these few individual fish would not likely jeopardize the continued existence of the humphead wrasse at USAG-KA (NMFS 2019; **Appendix C**).

Disturbance from human activity and equipment operation: Pre-flight human activity and equipment operation is not likely to adversely impact fish species near Illeginni Islet. Species such as sharks and manta rays are highly mobile animals which may exhibit avoidance behavior by leaving areas with increased vessel traffic or other human activity. However, animals are expected to return to normal distributions and behaviors soon after the disturbance has ceased; therefore, impacts are expected to be less than significant.

In the reef areas adjacent to the impact area at Illeginni Islet, reef-associated fish, including the humphead wrasse, may be disturbed by human activity in the event of a shoreline strike. If debris were to enter the marine environment, post-test operations would include debris recovery in these nearshore areas. Fish might be disturbed by humans conducting cleanup operations and have the potential to be disturbed or injured by equipment operation in the debris area of potential effect. Other potential stressors include noise from equipment operation and temporary increases in turbidity. The extent of the potential impact would be limited to the direct contact area of potential effect adjacent to the terrestrial impact area (**Figure 4-1**). Fish such as the humphead wrasse, which are normally patchy in distribution and usually present as solitary individuals or in very low numbers, might be present. However, due to their natural wariness, they are expected to shy well away from the divers or equipment and not be killed or injured. Any increases in turbidity associated with the operations would be temporary, and turbidity would likely return to background levels within a few hours of the activity's conclusion. Reef-associated fish may exhibit avoidance behavior, temporarily leaving the site of increased human activity, but there is no reason to expect that these fish would not return to these areas once the disturbance has ended.

The USAF concluded that human disturbance and/or equipment operation may adversely affect the humphead wrasse (USAF and USASMDC 2019) and initiated consultation with NMFS. In their Final BO (NMFS 2019; **Appendix C**), NMFS concluded that a total of up to 108 individuals could be affected near the Illeginni shoreline by the Proposed Action. The NMFS also concluded that the potential loss of these few fish would not likely jeopardize the continued existence of the humphead wrasse at USAG-KA (NMFS 2019; **Appendix C**).

<u>Exposure to hazardous chemicals</u>: Chemicals dispersed at Illeginni Islet are not expected to impact fish because most payload fragments and chemicals should be contained within terrestrial environments, all visible debris in terrestrial and shallow water (up to water depths of 15 to 30.5 m [49 to 100 ft]) would be recovered, and any soluble chemicals introduced into the marine environment are expected to be quickly dispersed and diluted by ocean currents and wave action.

<u>Corals and Mollusks</u>. Larval corals and mollusks of many species may be present in the waters near Illeginni Islet as drifting plankton during certain times of the year. Larval coral and mollusks have the potential to be impacted by direct contact from payload debris or ejecta, human disturbance or equipment operation, vessel strike, and/or exposure to hazardous chemicals. However, larval densities in this area are highly variable in space and time, and no reliable density data is available to allow calculation of the number of larvae which might be affected. Even though some individual larvae are likely to affected by ARRW test series 2 activities, the total number affected would be a very small (but undeterminable) number of the total larvae for coral and mollusk populations at Illeginni Islet or within Kwajalein Atoll. Therefore, any ARRW test series 2 effects on larval coral or mollusks are not expected to have adverse impacts on local or regional population size or distribution.

Non-larval corals and mollusks have the potential to be affected by direct contact from payload debris or ejecta, disturbance from human activity and equipment operation, and exposure to hazardous chemicals. Since at least some adult consultation corals, mollusks, and fish may be affected by direct contact, the USAF concluded that these activities may adversely affect these species (USAF and USASMDC 2019) and initiated consultation with NMFS. In their Final Biological Opinion (NMFS 2019; **Appendix C**), NMFS concluded that up to 10,417 UES consultation coral colonies, four top shell snails, and 90 clams might be injured or killed by the Proposed Action. The NMFS also concluded that the potential loss of these individuals snails, clams, and coral colonies would not likely jeopardize the continued existence of any of these UES consultation species at USAG-KA (NMFS 2019; **Appendix C**).

Direct contact: The extent of the area that may be subject to direct contact from payload debris or ejecta from impact is limited to the area within 91 m (300 ft) of the shoreline and only in the unlikely event of a shoreline impact (**Figure 4-1**). Several coral and mollusk species occur in reefs adjacent to the payload impact area at Illeginni Islet (**Table 3-8** and **Table 3-9**). In 2014 NMFS surveyed both the lagoon-side and ocean-side areas with the potential to be subject to direct contact effects (described in **Section 3.5.15.2**). The NMFS also estimated the density of consultation corals and mollusks in the direct contact areas of potential effect (**Table 4-6**). Based on species density and the estimated maximum area that would be affected by direct contact, the numbers of consultation coral colonies and individual mollusks that may be present were estimated for each species on the lagoon side and ocean side of Illeginni (**Table 4-6**). On the lagoon side, estimates of the maximum numbers of consultation coral colonies and individual mollusks were 4,725 and 79, respectively, in habitat affected by debris fall. On the ocean side, a maximum of 5,692 consultation coral colonies and 15 individual mollusks are expected to be in the area with the potential to be affected by direct contact from payload impact.

Table 4-6. Estimated Numbers of Consultation Coral Colonies and Individual Mollusks in Affected Habitats.[1]

Species	Ocean Side Debris Fall Area				Lagoon Side Debris Fall Area			
	Mean Colonies or Individuals (per m^2)	99% UCL (per m^2)	Affected Habitat (m^2)	# of Colonies or Individuals	Mean Colonies or Individuals (per m^2)	99% UCL (per m^2)	Affected Habitat (m^2)	# of Colonies or Individuals
Corals								
Acropora microclados	0.0004	0.0017	9,756	17				
Acropora polystoma	≤0.0004	0.0017	9,756	17				
Cyphastrea agassizi					0.0003	0.0013	10,406	14
Heliopora coerulea					0.16	0.45	10,406	4,683
Pavona venosa					0.0003	0.0013	10,406	14
Pocillopora meandrina	0.3	0.58	9,756	5,658				
Turbinaria reniformis					≤0.0003	0.0013	10,406	14
Coral Subtotal				5,692				4,725
Mollusks								
Hippopus	0.0003	0.0015	9,756	15	0.002	0.006	10,406	63
Tectus niloticus					0.00006	0.0003	10,406	4
Tridacna squamosa					0.0002	0.0011	10,406	12
Mollusk Subtotal				15				79

Abbreviations: m = meter; m^2 = square meter; UCL = Upper Confidence Limit
[1] The species in this table include those found during a 2004 assessment of the areas of potential effect (NMFS-PIRO 2017a and 2017b). Coral colony and individual mollusk mean densities and 99% UCL provided by NMFS-PIRO (2017a and 2017b).

Not every consultation species individual or colony within an affected area of habitat would be equally vulnerable to the effects of debris fall and shock wave impacts (U.S. Navy and USASMDC 2017, NMFS-PIRO 2017c). It is important to recall that the estimated numbers of colonies or individuals potentially affected are based on a worst-case scenario of a payload land impact. In the event of a shoreline impact it is likely that only a portion of the corals and mollusks present in the direct contact area would be affected. Payload impact would not be targeted close to the shoreline and impacts to nearshore consultation species would be avoided. The entire potential affected reef area is very small in comparison to the total comparable reef area surrounding and connected to Illeginni Islet. Moreover, this area is considered extremely small compared to sum of comparable reef areas in the USAG-KA area per the current military use agreement with the RMI, and very small in comparison with comparable reef areas within the entire atoll.

A summary of recorded distributions of these consultation coral species, based on observations made during USAG-KA inventories between 2010 and 2016, is shown in **Table 3-8**. A total of 125 sites were surveyed for protected corals since 2010 including Illeginni Harbor. These seven species of coral appear to be geographically widespread. Of the 7 coral species that have the potential to be affected by direct contact as adults, all were observed at multiple islets (at least 6 islets) and 5 of these species were observed at all 11 surveyed islets (**Table 3-8**). With the exception of *Acropora polystoma* (found at only 8% of sites) these species appear to be common throughout Kwajalein Atoll as well. Three species were found at approximately 30% of surveyed sites across the atoll (*Pavona venosa* at 32%, *Turbinaria reniformis* at 30%, and *Cyphastrea agassizi* at 28%) while *Acropora microclados* (82% of sites), *Heliopora coerulea* (61% of sites), and *Pocillopora meandrina* (96% of sites) were very common throughout Kwajalein Atoll (USAF and USASMDC 2019).

The three consultation mollusk species that are known to occur in the area subject to potential direct contact effects are found throughout Kwajalein Atoll as well (**Table 3-9**). *Hippopus hippopus* and *Tectus niloticus* have been observed at all 11 of the surveyed USAG-KA islets and *Tridacna squamosa* has been observed at 9 of the 11 islets (**Table 3-9**). These species are also relatively common, being found at 38% (*Hippopus hippopus*) to 63% (*Tectus niloticus*) of surveyed sites across the atoll since 2010 (USAF and USASMDC 2019).

While density estimates are not available for non-consultation coral and mollusk species in the direct contact area (**Table 3-8** and **Table 3-9**), some individuals of these species would likely be affected in the event of a shoreline impact. All of these species are present on islets throughout Kwajalein Atoll (**Table 3-8** and **Table 3-9**). All non-consultation coral species recorded in the direct contact area have been recorded during surveys of at least 9 of the 11 surveyed USAG-KA islets since 2010 (**Table 3-8**). Even in the event of a worst-case scenario shoreline impact, ARRW test series 2 activities are not likely to significantly impact the population of these species at Illeginni Islet or throughout Kwajalein Atoll.

<u>Disturbance from human activity and equipment operation</u>: Pre-flight human disturbance and equipment operation are not likely to impact corals and mollusks near Illeginni as these activities are not expected to enter the nearshore marine environment. In the unlikely event of a shoreline impact, human activity and equipment operation including debris recovery would likely affect some adult mollusks and coral colonies. These affects would be within the direct contact area of potential effect and the impacts on coral and mollusk species would be no greater than (and not in addition to) those described for direct contact above.

<u>Exposure to hazardous chemicals</u>: Considering the small quantities of hazardous materials contained in the batteries, the planned land impact, and the dilution and mixing capabilities of the ocean and lagoon waters, the battery materials released during payload impact should be of little consequence to any corals, mollusks, or other invertebrates in the area.

4.4 Summary of Potential Impacts to Resources and Impact Avoidance and Minimization

A summary of the potential impacts associated with each of the Action alternatives and the No Action Alternative and impact avoidance are presented in **Table 4-7**. Minimization measures are presented in **Table 4-8**.

Table 4-7. Potential Impacts Associated with the No Action Alternative and the Proposed Action Alternative 1

Location	Resource Area	No Action Alternative	Air-Launched Rapid Response Weapon (ARRW) Alternative 1
Point Mugu Sea Range (PMSR)	Noise	There would be no change to noise levels in the Regions of Influence (ROIs). Therefore, no significant impacts would occur from noise with implementation of the No Action Alternative.	The Proposed Action states that the ARRW test series 1 flight tests would occur offshore within PMSR. A sonic boom would occur in PMSR as a result of the Proposed Action, particularly when the ARRW reaches high speeds. No short-term, or long-term, significant impacts would occur from noise as a result of the ARRW test series 1 flight tests.
	Air Quality	Under the No Action Alternative, the flight tests would not occur and there would be no change to baseline air quality. No significant impacts to air quality or air resources would occur with implementation of the No Action Alternative.	The aerial drop by USAF aircraft of the ARRW test series 1 over PMSR is expected to take place at an altitude of 12.2 km (40,000 ft) and over the ocean, away from the coast. The effect of the Proposed Action on local PMSR air quality would be negated because the ARRW test series 1 aerial drop would take place over 914 m (3,000 ft), above the atmospheric inversion layer (U.S. Navy 2002). The Proposed Action would introduce atomic chlorine, aluminum oxide particles, and nitrogen oxides produced from emissions of hydrogen chloride during high-temperature afterburning reactions in the exhaust plume of the solid rocket motor propellent. This can contribute to long-term ozone depletion. The Proposed Action is for minimal flight tests over a reasonable period of time. The short duration of the flight test, the length of time between the flight tests, the low emissions of the rocket exhaust, and the ignition location offshore in PMSR collectively indicate that the Proposed Action would not cause any lasting effects to PMSR air quality.
	Biological	There would be no change to biological resources, and therefore, no significant impacts to biological resources from implementation of the No Action Alternative.	The proposed ARRW test series 1 flight tests would not significantly impact marine vegetation at PMSR, and no special status vegetation species occur at PMSR. During normal operation, there would be no impacts to marine vegetation. Overall, marine wildlife is not expected to be impacted by any ARRW test series 1 system stressors at PMSR. Though unlikely, any realized effects to marine mammals, sea turtles, fish, or invertebrates would be limited to short-term startle reactions, and animals would be expected to return to normal behaviors within minutes. It is not likely that any designated critical habitat, protected area, or essential fish habitat would be impacted by the ARRW test series 1 flight tests. The ARRW test series 1 air-drop would take place at least 93 km (50 nm) from land and would not impact any protected habitats.

Location	Resource Area	No Action Alternative	Air-Launched Rapid Response Weapon (ARRW) Alternative 1
Broad Ocean Area (BOA)	Air Quality	Under the No Action Alternative, the ARRW flight test would not occur and there would be no change to baseline air quality. No significant impacts to air quality or air resources would occur with implementation of the No Action Alternative.	Thermal decomposition of HTPB in a rocket-motor environment is assumed to undergo the following pathway: HTPB⟶C2H4 and light hydrocarbon species On a global scale, the quantity of ethylene and light hydrocarbon emissions from a single ARRW test series 1 or 2 flight test would represent a very small fraction of ethylene and hydrocarbons generated. Ethylene does not present a health hazard to humans or animals, as it is a naturally produced gas. Additionally, diffusion and winds would disperse the ethylene and hydrocarbons. No significant effect on ozone levels from ethylene and hydrocarbons is expected. Impacts from a singular ARRW test series 1 or 2 flight test would not be expected to have a significant impact on the upper atmosphere.
	Biological Resources	There would be no change to biological resources, and therefore, no significant impacts to biological resources from implementation of the No Action Alternative.	*Marine Wildlife*: Noise: Sonic booms overpressures would not exceed the physical injury thresholds for organisms in the BOA. There is a potential for behavioral disruption in fish and birds but only up to 2.2 m and 79 m (7.2 ft and 259 ft) respectively from the point/path of maximum sonic boom overpressures. Any realized effects would likely be limited to short-term startle reactions and fish and birds would be expected to return to normal behaviors within minutes. Therefore, no adverse impacts from sonic booms are expected. Splashdown pressures would not exceed the injury thresholds for mid- or low frequency cetaceans, pinnipeds, or sea turtles for any portion of the BOA. For high-frequency cetaceans, elevated sound levels from component splashdown exceed the TTS threshold in the BOA; however, the risk of a cetacean in the high-frequency hearing group being exposed to SPL high enough to cause TTS is extremely low. Marine wildlife may also be exposed to SPLs high enough to cause behavioral disturbance. While effects of elevated SPLs are possible, based on species abundance and distribution in the BOA, the chances of this occurring are likely very low. Any realized effects of elevated SPLs are likely to be temporary, behavioral modifications with no lasting effects. Therefore, no significant impacts from elevated SPLs are expected. Direct Contact: The chances of an ARRW component directly contacting a marine mammal are very low. The chances of direct contact with a sea turtle are also extremely low. Direct contact would not be expected to adversely impact marine mammals, sea turtles, birds, or fish in the BOA. Hazardous Chemicals: The release of hazardous materials carried onboard a launch vehicle would not significantly impact marine life. Hazardous materials would be rapidly diluted in the seawater, and larger and heavier vehicle components would sink fairly quickly to the ocean floor to depths where consultation organisms would likely not be in contact with these materials. Increased Human and Vessel Activity: Vessel traffic is common in this area, and the increase in human activity and vessel traffic in the BOA would be expected to be minimal; these activities would not be

Location	Resource Area	No Action Alternative	Air-Launched Rapid Response Weapon (ARRW) Alternative 1
			expected to adversely impact marine resources including threatened and endangered species.
United States Army Garrison–Kwajalein Atoll (USAG-KA), Republic of the Marshall Islands (RMI), Illeginni Islet	Cultural Resources	There would be no change to cultural resources under the No Action Alternative. Therefore, no impacts would occur to cultural resources with implementation of the No Action Alternative.	Archaeological surveys have not found indigenous cultural materials or evidence of subsurface deposits on Illeginni Islet. The Cold War-era properties potentially eligible for listing on the RMI NRHP are in the central and eastern portions of Illeginni Islet. Because a land impact would not occur in proximity to known or potential cultural resources on Illeginni Islet, implementation of the Proposed Action would not result in significant impacts to cultural resources.
	Noise	There would be no change to noise levels in the ROI. Therefore, no significant impacts would occur from noise with implementation of the No Action Alternative.	While meteorological conditions can influence peak SPLs, the sonic boom generated by the approaching payload is estimated to peak at less than 180 dB. At the point of impact, the sonic boom footprint would narrow and duration for sonic boom overpressures are expected to average 75 to 270 ms. Approximately 1 km^2 (0.4 mi^2) would be exposed to SPLs up to 170 dB. Noise model assumptions for estimating sonic boom overpressures likely lead to conservatively high estimates of sonic boom pressures and, therefore, conservative estimates of affected area. Mission vessel personnel may be required to use hearing protection. Noise levels during pre-test and post-flight activities at the pre-determined target site would occur in an unpopulated area without resident receptors. Therefore, no significant impacts would occur from noise with implementation of the Proposed Action.
	Public Health and Safety	There would be no change to public health and safety under the No Action Alternative.	For impact, there are no resident populations in proximity to Illeginni Islet. NOTAMs and NTMs would be issued to clear traffic from caution areas prior to the test. There would be no significant impacts to public health and safety from the Proposed Action.
	Hazardous Materials and Wastes	Under the No Action Alternative, there would be no change to hazardous materials and waste at Illeginni Islet.	Hazardous materials used in the payload would be limited to batteries, small electro-explosive devices, and a tungsten alloy. No solid or liquid propellants, depleted uranium, beryllium, or radioactive materials would be carried on the payload. Flight test personnel would remediate the impact site, all visible debris would be removed, and all equipment and materials would be recovered from Illeginni Islet. Any hazardous waste resulting from ARRW test series 2 flight test activities on Illeginni Islet would be disposed of in accordance with the UES. No significant impacts would occur from the Proposed Action.

Location	Resource Area	No Action Alternative	Air-Launched Rapid Response Weapon (ARRW) Alternative 1
	Biological Resources	There would be no change to biological resources under the No Action Alternative. Therefore, no impacts would occur to biological resources with implementation of the No Action Alternative.	Terrestrial Vegetation: The payload impact zone at Illeginni is previously disturbed habitat and is covered predominantly in impervious surface or managed vegetation. Therefore, no adverse impacts to terrestrial vegetation are expected. Terrestrial Wildlife: Noise: It is likely that birds would be exposed to SPLs high enough to cause behavioral disturbance. Any behavioral or physiological response is likely to be very brief and no adverse impacts to birds on or near Illeginni Islet are expected due to elevated SPLs. Direct Contact: While direct contact from payload debris may impact any birds in the impact zone, very few birds are expected to be within this area and the chances of direct contact are low. The USAF and the USASMDC have concluded that since no sea turtle nesting activity has been reported on Illeginni Islet in over 20 years, the probability of sea turtle nesting in the area is so low as to be discountable and that ARRW test series 2 activities may but are not likely to adversely affect nesting sea turtles (USAF and USASMDC 2019). The USFWS has concurred with this determination (Appendix A). Vessel Strike: No adverse impacts to birds are expected from vessels transiting to and from Illeginni Islet. Exposure to Hazardous Chemicals: Hazardous chemicals are not expected to impact birds at Illeginni Islet. While hazardous chemicals have the potential to impact nesting sea turtles, no sea turtle nesting activity has been recorded on Illeginni Islet in over 20 years; therefore, sea turtles are not expected to be adversely impacted. Human Disturbance: Disturbance from human activities and equipment operation has the potential to impact birds, especially nesting seabirds on Illeginni Islet; however, any disturbance is not expected to have a significant, long-term impact. Disturbance from human activities and equipment operation may but is not likely to adversely impact nesting sea turtles, sea turtle nests, and/or sea turtle nesting habitat. Marine Wildlife: Noise: The maximum SPLs for sonic booms and payload impact at the terminal end of payload flight do not exceed the physical injury thresholds for marine wildlife at USAG-KA. There is a potential for behavioral disruption near the payload impact point but only within 22 m (72 ft) of maximum sonic boom overpressures for cetaceans and sea turtles and 100 m (328 ft) for fish. Any realized effects would likely be limited to short-term startle reactions and marine wildlife would be expected to return to normal behaviors within minutes. Payload impact SPLs would result in SPLs above the injury threshold for fish but only out to 2.2 m (7.2 ft) from impact; since a land impact is planned, no fish would be physically injured by elevated sound pressures. There is a potential for behavioral disruption in sea turtles

Location	Resource Area	No Action Alternative	Air-Launched Rapid Response Weapon (ARRW) Alternative 1
			and fish near the payload impact point. While there is a chance that up to 20 green sea turtles and 7 hawksbill turtles may be exposed to SPLs high enough to elicit behavioral response, any response is expected to be temporary and turtles would be expected to return to normal behavior within minutes. Any behavioral disturbance in fish would likely be limited to a brief startle response and behaviors would quickly return to normal. Therefore, no adverse impacts are expected from elevated SPLs.
			Direct Contact: Payload impact is not expected to adversely affect cetaceans or sea turtles in the water through direct contact. Payload impact may adversely impact a very small, but indeterminable, number of larval fish, coral, or mollusks. The number of larvae potentially affected is likely to be trivially small relative to their population sizes and the effects are considered discountable. Based on analyses of a worst-case scenario of a shoreline impact, direct contact from payload debris may also affect up to 4,725 coral colonies, 79 individual mollusks, and 100 juvenile or 8 adult humphead wrasses. The National Marine Fisheries Service (NMFS) has been provided these analyses in a biological assessment, and they found that up to 10,417 UES consultation coral colonies, four top shell snails, 90 clams, and 108 humphead wrasses might be injured or killed by the Proposed Action. The NMFS also concluded that the potential loss of these individual fish, snails, and clams, and coral colonies would not likely jeopardize the continued existence of any of these UES consultation species at USAG-KA (NMFS 2019; Appendix C). Vessel Strike: Marine wildlife has the potential to be impacted by vessel strike primarily by being at the surface when a vessel travels through an area. Due to species characteristics, abundance, and distribution, and mitigation measures, no adverse impacts due to vessel strike are expected. Hazardous Chemicals: Post-flight cleanup of the impact area would include recovery/cleanup of all visible floating debris. Considering the small quantities of hazardous materials contained in the batteries, the planned land impact, and the dilution and mixing capabilities of the ocean and lagoon waters, the battery materials released during payload impact should be of little consequence to any cetaceans, fish, or sea turtles in the area. Human Disturbance: Cetaceans, sea turtles in the water, and most fish are unlikely to be adversely impacted by increased human activity or equipment operation at Illeginni Islet. In shallow waters near Illeginni, corals, mollusks, and reef-associated fish have the potential to be disturbed by shallow water debris recovery and/or backfill operations. NMFS has been provided a biological assessment, and the findings of their Final Biological Opinion are included in Appendix C.

Table 4-8. Impact Avoidance and Minimization Measures – ARRW

Location	Measure	Anticipated Benefit	Evaluating Effectiveness	Implementing and Monitoring	Responsibility
Broad Ocean Area (BOA) – Air-Launched Rapid Response Weapon (ARRW)					
	Payload's flight path would avoid flying over the Hawaiian Islands	Avoid impacts to protected species and habitats	Determine that actual flight path complies	Recordkeeping and reporting in accordance with DOD, USAF, and RTS range and flight safety policies and regulations, USFWS regulations, and the ESA and MMPA	USAF
	During travel in the BOA, ship personnel would monitor for marine mammals and sea turtles to avoid potential ship strikes. Vessel operators would adjust speed based on expected animal locations, densities, and/or lighting and turbidity conditions when possible.	Avoid impact on marine mammals and sea turtles.	Although unlikely, any dead or injured marine mammals or sea turtles sighted by post-flight personnel would be reported to USASMDC, who would then inform NMFS and USFWS.	Recordkeeping and reporting to the appropriate authorities	USAF, RTS
	Computer-monitored flight termination system	Avoid debris falling on inhabited or protected areas, ensure compliance with U.S. range operation standards and practices	Determine the rate of successful compliance and incident prevention	Recordkeeping and reporting in accordance with USAF and DOD range and flight safety policies and regulations	USAF
United States Army Garrison, Republic of the Marshall Islands (USAG-KA, RMI) Illeginni Islet – ARRW					
	Computer-monitored flight termination system	Avoid debris falling on inhabited or protected areas, ensure compliance with U.S. range operation standards and practices	Determine the rate of successful compliance and incident prevention	Recordkeeping and reporting in accordance with DOD, USAF, and RTS range and flight safety policies and regulations	USAF, RTS

Table 4-8. Impact Avoidance and Minimization Measures – ARRW

Location	Measure	Anticipated Benefit	Evaluating Effectiveness	Implementing and Monitoring	Responsibility
	Pre-flight monitoring by qualified personnel would be conducted on Illeginni Islet for sea turtles or sea turtle nests. On-site personnel would report any observations of sea turtles or sea turtle nests on Illeginni Islet to appropriate test and USAG-KA personnel to provide to NMFS.	Avoid impacts to sea turtles and sea turtle nests	Determine the rate of successful compliance and incident prevention or occurrence	For at least several weeks preceding the ARRW test series 2 launch, Illeginni Islet would be surveyed by pre-test personnel for sea turtles, sea turtle nesting activity, and sea turtle nests on a bi-weekly basis. If possible, personnel would inspect the area within days of the launch. If sea turtles or sea turtle nests are observed near the impact area, observations would be reported to appropriate test and USAG-KA personnel for consideration in approval of the launch and to NMFS. Recordkeeping and reporting in accordance with UES, DOD, USAF, and USFWS regulations	RTS/USAG-KA, USAF
	RTS would conduct range responsibilities.	Ensure appropriate launch preparation, including explosive safety, support to USAF and inter-range coordination	Determine the rate of successful compliance and incident prevention	Recordkeeping in accordance with UES, DOD, USAF, and RTS applicable policies and regulations	RTS

Table 4-8. Impact Avoidance and Minimization Measures – ARRW

Location	Measure	Anticipated Benefit	Evaluating Effectiveness	Implementing and Monitoring	Responsibility
	During travel to and from Illeginni Islet (and during potential raft deployment), ship personnel would monitor for marine mammals and sea turtles to avoid potential vessel strikes. Vessel operators would adjust speed (raft deployment) based on expected animal locations, densities, and/or lighting and turbidity conditions.	Avoid impact on marine mammals and sea turtles.	Although unlikely, any dead or injured marine mammals or sea turtles sighted by post-flight personnel would be reported to the USAG-KA Environmental Office and USASMDC, who would then inform NMFS and USFWS. USAG-KA aircraft pilots otherwise flying in the vicinity of the impact and test support areas would similarly report any opportunistic sightings of dead or injured marine mammals or sea turtles.	If personnel observe sea turtles or marine mammals in potential impact zones, sightings would be reported to appropriate test and USAG-KA personnel for consideration in launch planning, recordkeeping and reporting in accordance with UES, DOD, USAF, and RTS policies and regulations.	USAF, RTS
	Vessel and equipment operations would not involve any intentional discharges of fuel, toxic wastes, or plastics and other solid wastes that could harm terrestrial or marine life. Hazardous materials would be handled in adherence to the hazardous materials and waste management systems of USAG-KA. Hazardous material releases would comply with the emergency procedures set out in the KEEP and the UES.	Avoid introduction of hazardous chemicals into terrestrial and marine environments.	Determine the rate of successful compliance and incident prevention	Vessel and heavy equipment operators would inspect and clean equipment for fuel or fluid leaks prior to use or transport, recordkeeping of all incidents and outcomes	USAF, RTS

Table 4-8. Impact Avoidance and Minimization Measures – ARRW

Location	Measure	Anticipated Benefit	Evaluating Effectiveness	Implementing and Monitoring	Responsibility
	All equipment and packages shipped to USAG-KA would undergo inspection prior to shipment.	Prevent the introduction of alien species of plants and animals to Kwajalein Atoll	Determine the rate of successful prevention, identifying the need for treatment applications, as necessary	Recordkeeping of all inspections and outcomes	USAF
	Sensor rafts (if deployed) would not be located in waters less than 3 m (10 ft) deep.	To avoid impacts on coral heads off Illeginni Islet	Determine the rate of successful compliance and incident prevention	Recordkeeping of deployments and outcomes	USAF
	Publication and circulation of NOTAMs and NTMs prior to launch	Provide safety and warning to personnel, including private citizens and commercial entities, concerning any potential hazard areas that should be avoided; ensure the clearance of non-critical personnel, vessels or aircraft in the vicinity	Determine the rate of successful compliance and incident prevention	Recordkeeping in accordance with UES, DOD, USAF, and RTS policies and regulations	USAF, RTS
	Onboard flight termination system	Ensure the safety of the Marshall Islands and avoid debris falling on inhabited areas or any protected area, ensure compliance with U.S. range operation standards and practices	Determine the rate of successful compliance and incident prevention	Recordkeeping in accordance with UES, DOD, USAF, and RTS policies and regulations	USAF, RTS

Table 4-8. Impact Avoidance and Minimization Measures – ARRW

Location	Measure	Anticipated Benefit	Evaluating Effectiveness	Implementing and Monitoring	Responsibility
	Payload impact would be in the non-forested area; place scarecrows, Mylar flags, helium-filled balloons, and strobe lights or tarp coverings on or near equipment and the impact area.	Avoid affecting the bird habitat	Determine the rate of successful compliance and incident prevention or occurrence	Recordkeeping and reporting in accordance with UES, DOD, USAF, RTS, USFWS, and RMIEPA policies and regulations	USAF, RTS
	The impact area would be searched for seabird nests, including eggs and chicks, prior to pre-flight activity. Any discovered seabird nest would be covered with an A-frame structure to protect eggs or chicks and to warn project personnel.	Avoid impacts to seabirds, especially black-naped terns	Post-test monitoring to observe impacts to seabirds, especially black-naped terns, their nests, eggs, or chicks	Results of monitoring would be reported to USAG-KA Environmental and to USFWS.	USAF
	Debris recovery and site cleanup would be performed for land or shallow water impacts.	To minimize long-term risks to terrestrial and marine life	Comparison of recovered debris to known materials in the payload	All visible project- related debris would be recovered during post-flight operations, including debris in shallow lagoon or shallow ocean waters by range divers. In all cases, recovery and cleanup would be conducted in a manner to minimize further impacts on biological resources. Protected marine species including invertebrates would be avoided or effects to them would be minimized, which may include movement of these organisms out of the area likely to be affected.	USAF, RTS

Table 4-8. Impact Avoidance and Minimization Measures – ARRW

Location	Measure	Anticipated Benefit	Evaluating Effectiveness	Implementing and Monitoring	Responsibility
	Should any components or debris impact areas of sensitive biological resources (i.e., sea turtle nesting habitat or coral reef), USFWS and NMFS biologists would be allowed to provide guidance and/or assistance in recovery operations to minimize impacts on such resources.	Minimize impacts on terrestrial and marine biological resources	Determine whether components or debris impact sensitive resources, determine if USFWS and NMFS biologists were contacted and allowed to provide guidance	Recordkeeping and reporting in accordance with UES, DOD, USAF, RTS, USFWS, and NMFS policies and regulations	USAF
	Should personnel observe endangered, threatened, or other species requiring consultation moving into the area, work would be delayed until such species leave the area or were out of harm's way.	Avoid impacts to terrestrial and marine wildlife	Determine the rate of successful compliance and incident prevention	Recordkeeping and reporting with UES, DOD, USAF, RTS, USFWS, and RMIEPA policies and regulations	USAF
	Evacuation of personnel; publication and circulation of NOTAMs and NTMs; perform radar and visual sweeps of the hazard area immediately prior to test flights	Provide safety and warning to personnel, including native Marshallese citizens, concerning any potential hazard areas that should be avoided; ensure the clearance of non-critical personnel, vessels, or aircraft in the vicinity	Determine the rate of successful compliance and incident prevention	Recordkeeping in accordance with UES, DOD, USAF, and RTS policies and regulations	USAF, RTS
	Ordnance personnel survey of impact site, removal of residual explosive materials, manual cleanup and removal of debris including hazardous materials, backfill impact crater, dive team or remotely operated vehicle survey and	Ensure post-test personnel safety, avoid impacts to terrestrial and marine vegetation and wildlife	Determine the rate of successful compliance and incident prevention with appropriate disposition of recovered materials	Recordkeeping in accordance with UES, DOD, USAF, and RTS policies and regulations	RTS

Table 4-8. Impact Avoidance and Minimization Measures – ARRW

Location	Measure	Anticipated Benefit	Evaluating Effectiveness	Implementing and Monitoring	Responsibility
	debris recovery in lagoon				
	Inspect reef, reef flat, or shallow waters within 24 hours if inadvertently impacted, assess damage, and decide on any mitigation measures	Avoid or minimize impacts to marine vegetation and wildlife	Determine the rate of successful compliance and incident prevention	Recordkeeping and reporting in accordance with UES, DOD, USAF, RTS, and RMIEPA policies and regulations	RTS, USAF, possibly NMFS/USFWS
	Ensure that all relevant personnel associated with this project are fully briefed on the BMPs and the requirement to adhere to them for the duration of this project.	Ensure awareness of and application of BMP for the duration of the ARRW flight test	Determine the rate of successful compliance and incident prevention	Recordkeeping in accordance with UES, DOD, USAF, RTS, USFWS, and NMFS policies, regulations, and guidance	USAF
	In the event the ARRW test series 2 payload and impact affects the reef at Illeginni, personnel shall 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. Ejecta greater than 15.24 cm (6 in.) 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. If possible, coral fragments greater than 15.24 cm (6 in.) in any dimension shall be positioned on the reef such that they would not become mobilized by expected wave action, and in a	Avoid impacts to marine wildlife, determine impacts to reef and disposition of ejecta	Determine the rate of successful compliance and incident prevention	Recordkeeping and reporting in accordance with UES, DOD, USAF, RTS, USFWS, and NMFS policies, regulations, and guidance	USAF, USAG-KA

Table 4-8. Impact Avoidance and Minimization Measures – ARRW

Location	Measure	Anticipated Benefit	Evaluating Effectiveness	Implementing and Monitoring	Responsibility
	manner that would enhance its survival; away from fine sediments with the majority of the living tissue (polyps) facing up. UES consultation coral fragments that cannot be secured in-place should be relocated to suitable habitat where it is not likely to become mobilized.				
	In the event the ARRW test series 2 payload land impact affects the reef at Illeginni, USASMDC shall require its personnel to reduce impacts on top shell snails. Rescue and reposition any living top shell snails that are buried or trapped by rubble. 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.	Avoid impacts to marine wildlife	Post-test monitoring to observe impacts to reef and top shell snails, and determine disposition of ejecta	Recordkeeping and reporting in accordance with UES, DOD, USAF, RTS, USFWS, and NMFS policies, regulations, and guidance	USAF, USAG-KA

Table 4-8. Impact Avoidance and Minimization Measures – ARRW

Location	Measure	Anticipated Benefit	Evaluating Effectiveness	Implementing and Monitoring	Responsibility
	In the event the ARRW test series 2 payload land impact affects the reef at Illeginni Islet, personnel shall be required to reduce impacts on clams. Rescue and reposition any living clams that are buried or trapped by rubble. Relocate to suitable habitat, any living clams that are in the path of any heavy equipment that must be used in the marine environment.	Avoid impacts to marine wildlife	Post-test monitoring to observe impacts to reef and living clams, and determine disposition of ejecta	Recordkeeping and reporting in accordance with UES, DOD, USAF, RTS, USFWS, and NMFS policies, regulations, and guidance	USAF, USAG-KA
	Appropriately qualified personnel shall be assigned to record all suspected incidences of take of any UES-consultation species.	Ensure accuracy of data collection and applicability to incidences of take.	Identification or refutation of all suspected incidences of take	Recordkeeping and reporting in accordance with UES, DOD, USAF, RTS, USFWS, and NMFS policies, regulations, and guidance	USAF, USAG-KA

Table 4-8. Impact Avoidance and Minimization Measures – ARRW

Location	Measure	Anticipated Benefit	Evaluating Effectiveness	Implementing and Monitoring	Responsibility
	Digital photography shall be utilized to record any UES-consultation species found injured or killed in or near the ocean target areas and/or at Illeginni Islet. 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.	Ensure accuracy of data collection and applicability to incidences of take	Photo-documentation prepared as per NMFS guidance	Recordkeeping and reporting in accordance with UES, DOD, USAF, RTS, USFWS, and NMFS policies, regulations, and guidance	USAF, USAG-KA
	In the event the ARRW test series 2 payload impact affects the reef at Illeginni Islet, personnel shall survey the ejecta field for impacted corals, top shell snails, and clams within 60 days of completing post-test clean-up and restoration. Also, be mindful of any other UES-consultation species that may have been affected.	Avoid impacts to marine wildlife; ensure accuracy of data collection and applicability to incidences of take	Post-test monitoring to observe impacts to reef and identified organisms, including UES consultation species	Recordkeeping and reporting in accordance with UES, DOD, USAF, RTS, USFWS, and NMFS policies, regulations, and guidance	USAF, USAG-KA

Table 4-8. Impact Avoidance and Minimization Measures – ARRW

Location	Measure	Anticipated Benefit	Evaluating Effectiveness	Implementing and Monitoring	Responsibility
	Within several days of completing post-test clean-up and restoration, provide photographs and records to the USAG-KA Environmental Office. USAG-KA and NMFS biologists would review the photographs and records to identify the organisms to the lowest taxonomic level accurately possible to assess impacts on consultation species.	Ensure accuracy of data collection and applicability to incidences of take	Submittal of photographs and records within several days of completing post-test clean-up and restoration	Recordkeeping and reporting in accordance with UES, DOD, USAF, RTS, USFWS and NMFS policies, regulations, and guidance	USAF, USAG-KA
	Within months of completion of the action, USAF shall provide a report to USAG-KA to forward to NMFS. 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.	Ensure compliance with UES and NMFS Biological Opinion Terms and Conditions	Submittal of report within months of completing the action	Recordkeeping and reporting in accordance with UES, DOD, USAF, RTS, USFWS and NMFS policies, regulations, and guidance	USAF, USAG-KA
	Prepare a project specific NPA and DEP	Ensure UES compliance	Complete the NPA and DEP prior to occurrence of the Proposed Action	Final DEP authorized with UES Appropriate Agencies' signatures prior to occurrence of the Proposed Action	USAF

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5.0 Cumulative Impacts

This chapter (1) defines cumulative impacts; (2) describes past, present, and reasonably foreseeable future actions relevant to cumulative impacts; (3) analyzes the incremental environmental impacts the Proposed Action may have with other actions; and (4) evaluates cumulative impacts potentially resulting from these interactions.

5.1 Definition of Cumulative Impacts

The approach taken in the analysis of cumulative impacts follows the objectives of NEPA, CEQ regulations, and CEQ guidance. Cumulative impacts are defined in 40 CFR Section 1508.7 as the impact on the environment that results from the incremental impact of the action when added to the other past, present, and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over time.

To determine the scope of environmental effects, agencies shall consider cumulative actions, which when viewed with other proposed actions have cumulatively significant impacts and should therefore be discussed in the same impact document.

In addition, CEQ and USEPA have published guidance addressing implementation of cumulative impact analyses—Guidance on the Consideration of Past Actions in Cumulative Effects Analysis (CEQ 2005) and Consideration of Cumulative Impacts in USEPA Review of NEPA Documents (USEPA 1999). CEQ guidance entitled Considering Cumulative Impacts Under NEPA (1997) states that cumulative impact analyses should:

> "…determine the magnitude and significance of the environmental consequences of the proposed action in the context of the cumulative impacts of other past, present, and future actions...identify significant cumulative impacts…[and]…focus on truly meaningful impacts."

Cumulative impacts are most likely to arise when a relationship or synergism exists between a proposed action and other actions expected to occur in a similar location or during a similar time period. Actions overlapping with or in close proximity to the proposed action would be expected to have more potential for a relationship than those more geographically separated. Similarly, relatively concurrent actions would tend to offer a higher potential for cumulative impacts. To identify cumulative impacts, the analysis needs to address the following three questions.

- Does a relationship exist such that affected resource areas of the proposed action might interact with the affected resource areas of past, present, or reasonably foreseeable actions?

- If one or more of the affected resource areas of the proposed action and another action could be expected to interact, would the proposed action affect or be affected by impacts of the other action?
- If such a relationship exists, does an assessment reveal any potentially significant impacts not identified when the Proposed Action is considered alone?

5.2 Scope of Cumulative Impacts Analysis

The scope of the cumulative impacts analysis involves both the geographic extent of the effects and the time frame in which the effects could be expected to occur. For this EA/OEA, the study area would include those areas previously identified in **Chapter 4.0** for each resource area. The time frame for cumulative impacts centers on the timing of the Proposed Action (several months after signing the FONSI). It also includes the time it might take for effects from the flight tests to develop, such as dissolution of tungsten in the soil.

Another factor influencing the scope of cumulative impacts analysis involves identifying other actions to consider. Beyond determining that the geographic scope and time frame for the actions interrelate to the Proposed Action, the analysis employs the measure of “reasonably foreseeable” to include or exclude other actions. For the purposes of this analysis, public documents prepared by federal, state, and local government agencies form the primary sources of information regarding reasonably foreseeable actions. Documents used to identify other actions include notices of intent for EISs and EAs, management plans, land use plans, and other planning related studies.

5.3 Past, Present, and Reasonably Foreseeable Actions

This section focuses on past, present, and reasonably foreseeable future projects at and near PMSR, the Pacific BOA and RTS, Kwajalein Atoll (Illeginni Islet). In determining which projects to include in the cumulative impacts analysis, a preliminary determination was made regarding the past, present, or reasonably foreseeable action. Projects included in this cumulative impact analysis are listed in **Table 5-1** and briefly described in the following subsections.

Table 5-1. NEPA Analyses Performed for Actions Considered in Cumulative Impacts Evaluation

Location	Action	Level of NEPA Analysis Completed
PMSR	Present and Reasonably Foreseeable Future Actions	
	Tactical Boost Glide	EA/FONSI (Expected)
	DARPA Launch Challenge	EA/FONSI (Expected)
Broad Ocean Area	Past Actions	
	Minuteman III Flight Testing	EA/FONSI
	Advanced Hypersonic Weapon Flight Testing	EA/FONSI
	Present and Reasonably Foreseeable Future Actions	
	Minuteman III Flight Testing	(S)EA/FONSI
	U.S. Air Force Air Launched Rapid Response Weapon (ARRW)	EA/FONSI (Expected)
U.S. Army Garrison–Kwajalein Atoll, Republic of the Marshall Islands Illeginni Islet	Past Actions	
	Minuteman III Reentry Vehicle Impacts	EA/FONSI
	U.S. Navy Strategic Systems Programs Flight Experiment-1	EA/FONSI
	Present and Reasonably Foreseeable Future Actions	
	U.S. Navy SSP Flight Experiment-2	EA/FONSI
	Department of the Army Hypersonic Flight Test -3	EA/FONSI (Expected)

Notes: EA = Environmental Assessment; FONSI = Finding of No Significant Impact; NEPA = National Environmental Policy Act; S = Supplemental

5.3.1 Past Actions

There have been fewer than 10 STARS launches in the last 25 years. The Advanced Hypersonic Weapon program had a single payload that previously impacted at Illeginni Islet following a launch using a STARS booster. The most recent STARS launch with an impact at Illeginni Islet was in 2017 for FE-1. Other past actions have included testing and training for U.S. Navy and other Government agencies. Actions have included research, development, test and evaluation (RDT&E) activities in the HRC, Major Exercises, and maintenance of the technical and logistical facilities that support these activities and exercises.

MMIII ICBM missile reentry vehicles have routinely impacted at Illeginni Islet in the past. An EA with a FONSI was completed for MMIII modifications in 2004, and a Supplemental EA is in process for additional missile configuration updates (2017). Both beryllium and depleted uranium remain in the soil at Illeginni Islet from MMIII land impacts.

5.3.2 Present and Reasonably Foreseeable Actions

The actions associated with testing and training for U.S. Navy and other Government agencies are still occurring and are expected to occur well into the future. The actions that include RDT&E

activities in the HRC, Major Exercises, and maintenance of the technical and logistical facilities that support these activities and exercises are also still occurring and are expected to continue. The Flight Experiment 2 (FE-2) flight test is expected to be similar to FE-1 and USAF ARRW with impact at Illeginni Islet.

5.4 Cumulative Impact Analysis

For most resources included for analysis, quantifiable data are not available, and a qualitative analysis was undertaken. In addition, where an analysis of potential environmental effects for future actions has not been completed, assumptions were made regarding cumulative impacts related to this EA/OEA where possible. The analytical methodology presented in **Chapter 4.0**, which was used to determine potential impacts to the various resources analyzed in this document, was also used to determine cumulative impacts.

5.4.1 Point Mugu Sea Range

5.4.1.1 Description of Geographic Study Area

Point Mugu is located off the Pacific Coast of Southern California and supports test and evaluation of sea, land, and air weapons systems. PMSR provides a safe volume of air and sea space in which to conduct controlled tests (U.S. Navy 2002). PMSR is the geographic study area for cumulative impacts from the ARRW test series 1 flight tests and other relevant past, present, and future actions. There has been no significant change in cultural resources, biological resources, noise, public health and safety, and hazardous materials and wastes at PMSR.

5.4.1.2 Relevant Past, Present, and Future Actions

Regarding sea, land, and air weapons systems, five categories of tests were evaluated: (1) air-to-air tests, (2) air-to-surface tests, (3) surface-to-air tests, (4) surface-to-surface tests, and (5) subsurface-to-surface tests. Since the 2002 PMSR EIS/OEIS, Theater Missile Defense and increased training exercises have flourished as well. The upcoming 2021 EIS/OEIS Proposed Actions include testing and training activities that have already occurred at PMSR for decades, increased frequency of activities, new mission areas, and new platforms (aircraft and vessels).

NAWCWD Point Mugu already employs resource protection programs for its land and sea area and is expected to continue mitigative measures where possible into the future.

5.4.1.3 Cumulative Impact Analysis

Ongoing projects and proposed actions that will be detailed in the 2021 EIS/OEIS/ROD would likely be within the same geographical region of influence as the ARRW Proposed Action. However, the ARRW aerial drops that may occur as a result of the Proposed Action would happen at high altitudes (approximately 12.2 km [40,000 ft]), offshore, and most likely from varied drop points within PMSR. The cumulative impacts of the test series 1 aerial drops would not be significant overall.

Behavioral changes of marine wildlife from SPLs, disturbance from human activity, and exposure to hazardous chemicals that may occur are unlikely to be permanent. Marine wildlife may experience a startle reaction due to noise impacts but are expected to resume normal activity within minutes after the Proposed Action takes place.

No past, present, or reasonably foreseeable actions have been identified in PMSR that might interact with the affected resource areas of the Proposed Action (ARRW test series 1 flight test) and result in significant cumulative impacts.

5.4.2 Broad Ocean Area

5.4.2.1 Description of Geographic Study Area

The BOA between aerial launch and RTS, Illeginni Islet is the geographic study area for cumulative impacts from ARRW test series 1 and 2 flight tests, and other relevant past, present, and future actions. There has been no known significant change in air quality or biological resources within the BOA.

5.4.2.2 Relevant Past, Present, and Future Actions

MMIII ICBM missile testing between Vandenberg AFB, California, and RTS has occurred and will continue to occur on an annual basis. Up to four MMIII missile flight tests would be conducted annually through 2030, and four Fuze Modernization flight tests would occur over a 4-year period. EAs with FONSIs were prepared for the MMIII missile testing in 2001 and 2004. An additional Supplemental EA is in process for the Modification and Fuze Modernization flight tests through 2030. The trajectory for these flights partially overlaps the BOA and impacts at RTS, Illeginni Islet.

In November 2011, USASMDC/ARSTRAT performed a test flight of the Advanced Hypersonic Weapon concept. The test vehicle was launched from the Kauai Test Facility to RTS. The flight path for this flight test overlapped portions of the BOA and impacted at RTS, similar to ARRW. In October 2017 the U.S. Navy SSP performed the FE-1 flight test with essentially the same over-ocean flight corridor as the Advanced Hypersonic Weapon, overlapping portions of the BOA and impacting at RTS, Illeginni Islet.

In FY 2021 USASMDC is anticipated to test the FT-3 hypersonic weapon system from Pacific Spaceport Complex Alaska to USAG-KA. The FT-3 test will be stool-launched from Kodiak, Alaska, but the payload impact scenario is expected to be similar to the ARRW test series 2 impact scenario.

A third U.S. Navy SSP flight test (FE-3) is being considered as a future action. Details are not available, but the third flight would probably be like FE-1 and ARRW. Discussions regarding FE-3 are at least a year in the future, and no specifics are currently available. The flight path for FE-3 may have a similar over-ocean flight corridor between Kauai Test Facility and RTS as FE-1 and FE-2, overlapping the BOA (as associated with the ARRW test series 1 and 2 flight test).

5.4.2.3 Cumulative Impact Analysis

Although there have been several missile flight tests within the same or part of the same over-ocean flight corridor as the ARRW test series 1 and 2 flight tests, most of these flight tests used the STARS propulsion system or a launch vehicle of comparable size. As shown in **Section 4.1.14.2**, the solid rocket motor associated with the ARRW test series 1 and 2 flight tests is relatively small, and on a global scale the level of emissions from each ARRW test series 1 and 2 flight test would not be statistically significant. Because the emissions of ethylene hydrocarbons from each test flight would be relatively small, the air volume over which these emissions are spread is large, the emissions are rapidly dispersed by stratospheric winds, and the length of time between discrete launches is measured in months, these flight tests within the BOA would not have a significant cumulative impact. Therefore, cumulative impacts from the ARRW test series 1 and 2 flight tests and the other evaluated flight tests would not be expected to have a significant impact on the upper atmosphere or stratospheric ozone depletion.

Impacts to biological resources within the BOA for past and future flight tests were not identified as being significant. As with the Proposed Action, the potential for impacts from noise or direct contact from solid rocket motor ignition, flight and component splash down for past, present, and future activities was extremely low given the size of the area, the size of the components, and the low densities of marine species within the BOA. None of these actions are expected to interact to produce cumulative effects for biological resources.

No past, present, or reasonably foreseeable actions have been identified in the BOA that might interact with the affected resource areas of the Proposed Action and result in significant cumulative impacts.

5.4.3 U.S. Army Garrison–Kwajalein Atoll – Illeginni Islet

5.4.3.1 Description of Geographic Study Area

The northwest end of Illeginni Islet is the geographic study area for cumulative impacts from ARRW test series 2 and other relevant past, present, and future actions. There has been no significant change in cultural resources, biological resources, noise, public health and safety, and hazardous materials and wastes at Illeginni Islet. Although there is beryllium and depleted uranium in the soil at Illeginni Islet from past MMIII reentry vehicles' impacts, analytical results indicate the levels are below USEPA residential regulatory limits. (Robison et al. 2013) The United

States Army Public Health Command (USAPHC) Fish Study (2014) noted that “unacceptable cancer risk for Marshallese adults at Illeginni [harbor] is attributable to the pesticide, chlordane.” Chlordane is a pesticide used to treat wood and wood structures for control of pests, particularly termites, and is not associated with previous missile flight tests impacting at Illeginni.

Soils and groundwater at Illeginni Islet are currently undergoing testing for tungsten released during FE-1 testing. Results of the second set of tungsten tests (subsequent to FE-1 testing) will be incorporated into this document as soon as results are available. Because the debris from FE-1 has been removed, and debris from the ARRW test series 2 will be removed from the impact location, the potential for cumulative impacts is low.

5.4.3.2 Relevant Past, Present, and Future Actions

MMIII ICBM missile testing between Vandenberg AFB, California, and RTS (Illeginni Islet) has occurred and will continue to occur on an annual basis. Up to four MMIII missile flight tests would be conducted annually through 2030, and four Fuze Modernization flight tests would occur over a 4-year period. In 2016, United States Air Force Global Strike Command (USAFGSC) determined that land impacts at Illeginni Islet would no longer occur. EAs with FONSIs were prepared for the MMIII missile testing in 2001 and 2004. An additional Supplemental EA is in process for the Modification and Fuze Modernization flight tests through 2030. Past reentry vehicle impacts occurred on Illeginni Islet; future reentry vehicle impacts would only occur at the KMISS. For past flight tests, the impact crater was screened for debris and all other visible debris from around the impact was manually recovered and disposed of in accordance with the UES.

The FE-1 flight test was completed in October 2017; an EA/OEA was prepared for FE-2 and a FONSI was signed in December 2019; and a third flight test (FE-3) is being considered as a future action. Discussions are at least a year in the future regarding a third flight test, and no specifics are currently available.

5.4.3.3 Cumulative Impact Analysis

MMIII ICBM missile testing from Vandenberg AFB, California, to Illeginni Islet has occurred in the past. Beryllium and depleted uranium from past MMIII reentry vehicles’ impacts remain in the soil at Illeginni Islet; analytical results indicate the levels are below USEPA residential regulatory limits (Robison et al. 2013). No future MMIII impacts are planned for Illeginni Islet. MMIII flight tests have been and will continue to be conducted in accordance with biological opinions from NMFS and USFWS, in addition to program specific DEPs and the UES.

The Advanced Hypersonic Weapon flight and FE-1 Flight Test were conducted in accordance with the Illeginni Impacts DEP and the UES. Payload impacts were less than those of the MMIII reentry vehicles (USASMDC/ARSTRAT 2011). There was no significant impact to resources at Illeginni Islet from the Advanced Hypersonic Weapon flight test and FE-1 Flight Test.

A 2008 study of geochemical parameters influencing tungsten mobility in soils (Bednar et al. 2008) found that dissolved tungsten reached equilibrium in soil after approximately 48 hours and mobility decreased by approximately one-half within a 4-month period. The "long term known impact or potential risk", as identified during peer review by the RMIEPA (2017), is not conclusively identified in peer reviewed literature. Based on the quantities of tungsten in FE-1 and planned for ARRW test series 2 vehicle the bench study and model results indicate levels of tungsten in Illeginni Islet soil would be below the USEPA Residential RSLs (LLNL 2017) for soil and drinking water (although this area is not designated as potable drinking water) from the end of the flight test to 25 years out, the period for which the model was run.

The accumulation of tungsten following the ARRW test series 2 flight tests could potentially approach or exceed USEPA Residential RSLs for groundwater although this area is not designated as potable drinking water. Sampling of tungsten and other alloy metals in soil at Illeginni was conducted after FE-1 and final analyses are currently in process. Sampling and analyses would also be planned after the ARRW test series 2 flight tests. If analyses of FE-1 or ARRW test series 2 post-flight test soil samples indicate tungsten levels above RSLs, phytoremediation, using plants to draw up metals from the soil, would be considered, as suggested by the USEPA. Any type of remediation would only occur after field-portable elemental analysis such as laser-induced breakdown spectroscopy, or other in-situ detection systems, to determine the level of tungsten remaining in the soil and a need for additional cleanup to bring the concentration of tungsten in soil below the USEPA Industrial RSLs. If phytoremediation were employed, following an initial growth period, the plants would be removed, and laboratory analyzed to determine their effectiveness. Any plant remains would then be appropriately disposed of as hazardous waste in accordance with the UES.

The ARRW Proposed Action would not be expected to have significant or lasting impacts on terrestrial biological resources at Illeginni Islet. With the possible exception of tungsten accumulation, discussed above, no interactions are expected which would lead to cumulative impacts to terrestrial biological resources. As with MMIII and FE-1, the ARRW test series 2 flight test has the potential to affect marine biological resources including seven consultation coral species, three consultation mollusk species, and the humphead wrasse. Marine habitats will not be targeted; however, the worst-case of scenario of a shoreline strike for any of these actions has the potential to affect marine biological resources. While each of these actions has the potential to affect marine biological resources, there would be no interactive effects that would result in additional impacts to marine resources greater than those analyzed for an individual action. Therefore, ARRW test series 2 flights would not be expected to contribute to any cumulative biological resource impacts.

No other past, present, or reasonably foreseeable actions have been identified at Illeginni Islet that might interact with the affected resource areas of the Proposed Action and result in significant cumulative impacts.

6.0 Other Considerations Required by NEPA

6.1 Consistency with Other Federal, State, and Local Laws, Plans, Policies, and Regulations

In accordance with 40 CFR Section 1502.16(c), analysis of environmental consequences shall include discussion of possible conflicts between the Proposed Action and the objectives of federal, regional, state, and local land use plans, policies, and controls. **Table 6-1** identifies the principal federal and state laws and regulations that are applicable to the Proposed Action and indicates if the Proposed Action would be in compliance with these laws and regulations.

6.1.1 Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations (EO 12898)

An Environmental Justice analysis is included in this document to comply with the intent of EO 12898, and U.S. Army and DOD guidance. The EO states that "each federal agency shall make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations." In addition, the EO requires that minority and low-income populations be given access to information and opportunities to provide input to decision making on federal actions.

This EA/OEA has identified no human health, environmental, or other effects by the Proposed Action that would result in disproportionately high or adverse effect on minority or low income-populations in the areas evaluated. The Proposed Action activities also would be conducted in a manner that would not exclude persons from participating in, deny persons the benefits of, or subject persons to discrimination because of their race, color, national origin, or socioeconomic status.

6.1.2 Federal Actions to Address Protection of Children from Environmental Health Risks and Safety Risks (EO 13045, as Amended by EO 13229 and 13296)

This EA/OEA has not identified any environmental health and safety risks that may disproportionately affect children, in compliance with EO 13045, as amended by EO 13229 and 13296.

Table 6-1. Principal Federal and State Laws Applicable to the Proposed Action

Federal, State, Local, and Regional Land Use Plans, Policies, and Controls	Status of Compliance
National Environmental Policy Act (NEPA) (42 United States Code [USC] Section 4321 et seq.); Council on Environmental Quality (CEQ) NEPA implementing regulations (40 Code of Federal Regulations [CFR] parts 1500-1508; Navy procedures for Implementing NEPA (32 CFR Part 775 and Chief of Naval Operations Instruction [OPNAVINST] 5090.1D)	Compliant
Clean Air Act (42 USC § 7401 et seq.)	Compliant
Clean Water Act (33 USC § 1251 et seq.)	Compliant
Coastal Zone Management Act (16 USC § 1451 et seq.)	Compliant
National Historic Preservation Act (Section 106, 16 USC § 470 et seq.)	Compliant
Endangered Species Act (16 USC § 1531 et seq.)	Compliant
Marine Mammal Protection Act (16 USC § 1361 et seq.)	Compliant
Migratory Bird Treaty Act (16 USC § 703-712)	Compliant
Magnuson-Stevens Fishery Conservation and Management Reauthorization Act (16 USC § 1801 et seq.)	Compliant
U.S. Public Law 108-188, Compact of Free Association Amendments Act of 2003	Compliant
Executive Order 11988, Floodplain Management	Compliant
Executive Order 12088, Federal Compliance with Pollution Control Standards	Compliant
Executive Order 12114, Environmental Effects Abroad of Major Federal Actions	Compliant
Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-income Populations	Compliant
Executive Order 13045, Protection of Children from Environmental Health Risks and Safety Risks	Compliant
Executive Order 13089, Coral Reef Protection	Compliant
Executive Order 13423, Strengthening Federal Environmental, Energy, and Transportation Management	Compliant
Executive Order 13175, Consultation and Coordination with Indian Tribal Governments	Compliant
Executive Order 13696, Planning for Federal Sustainability in the Next Decade	Compliant

6.2 Coastal Zone Management

The federal CZMA of 1972 establishes a federal–state partnership to provide for the comprehensive management of coastal resources. Coastal states and territories develop site-specific coastal management programs based on enforceable policies and mechanisms to balance resource protection and coastal development needs.

The vast majority of the coasts throughout the RMI are in pristine natural condition. However, as foreign aid has centralized the economy and rapidly increasing populations in several urban centers with little environmental oversight, the urban coasts and environment have become severely degraded. For this reason, the *National Coastal Management Framework*, called for under the Coast Conservation Act of 1988 (CCA), was produced by the RMIEPA to review coastal conditions and activities as well as recommend proposals for action and policy for the RMI in 2008 to achieve a sustainable coastal zone of the RMI.

However, if the proposed federal activity affects coastal resources or uses beyond the boundaries of the federal property (i.e., has spillover effects), the CZMA Section 307 federal consistency requirement applies. As a federal agency, the USAF is required to determine whether its proposed activities would affect the coastal zone. This takes the form of either a Negative Determination or a Consistency Determination.

6.3 Relationship Between Short-Term Use of the Environment and Long-Term Productivity

NEPA requires an analysis of the relationship between a project's short-term impacts on the environment and the effects that these impacts may have on the maintenance and enhancement of the long-term productivity of the affected environment. Impacts that narrow the range of beneficial uses of the environment are of particular concern. This refers to the possibility that choosing one site reduces future flexibility in pursuing other options, or that using a parcel of land or other resources often eliminates the possibility of other uses at that site.

Operations related to the ARRW test series 1 and 2 flight tests would not significantly impact the long-term natural resource productivity in any of the Proposed Action areas. The Proposed Action would not result in any impacts that would significantly reduce environmental productivity or permanently narrow the range of beneficial uses of the environment.

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REPLY TO
ATTENTION OF

January 31, 2019

Dan A. Polhemus, PhD
U.S. Fish and Wildlife Service
Pacific Islands Fish and Wildlife Office
P.O. Box 50088
Honolulu, Hawaii 96850

Dear Dr. Polhemus,

The U.S. Army Space and Missile Defense Command / Army Forces Strategic Command (USASMDC/ARSTRAT) is assisting the U.S. Air Force Life Cycle Management Center (USAF/LCMC), the action proponent, in evaluating the effects of flight tests of the Air-launched Rapid Response Weapon (ARRW). We have prepared a Biological Assessment (BA) to evaluate the effects of the proposed action on species protected under Section 3-4.5 of the U. S. Army Kwajalein Atoll Environmental Standards (UES), Section 7 (a)(2) of the U.S. Endangered Species Act (ESA), and in connection with Section 101 of the Marine Mammal Protection Act (MMPA). There is no affected critical habitat for any of the protected species in the proposed action area.

As described in the enclosed BA, UES, ESA, and MMPA protected species occur or have the potential to occur in the action area. Based on analyses of all of the potential stressors resulting from the proposed action, we have concluded that the proposed action may affect and is likely to adversely affect some of these species and have initiated formal consultation with the National Marine Fisheries Service. These include one fish species, *Cheilinus undulatus*; three mollusk species, *Hippopus hippopus*, *Tectus niloticus*, and *Tridacna squamosa*; and seven coral species, *Acropora microclados*, *A. polystoma*, *Cyphastrea agassizi*, *Heliopora coerulea*, *Pavona venosa*, *Pocillopora meandrina*, and *Turbinaria reniformis*.

We have concluded that the proposed action may affect but is not likely to adversely affect 29 cetacean species, 4 pinniped species, 4 seabird species, 5 sea turtle species, 6 fish species, 15 coral species, 2 mollusk species, and larval fish, coral, and mollusks. These species include the cetacean species *Balaenoptera acutorostrata*, *B. boralis*, *B. edeni*, *B. musculus*, *B. physalus*, *Delphinus delphis*, *Feresa attenuata*, *Globicephala macrorhynchus*, *Grampus griseus*, *Indopacetus pacificus*, *Kogia breviceps*, *K. sima*, *Lagenodelphis hosei*, *Lissodelphis borealis*, *Megaptera novaeangliae*, *Mesoplodon carlhubbsi*, *M. densirostris*, *M. ginkgodens*, *Orcinus orca*, *Peponocephala electra*, *Phocoenoides dalli*, *Physeter macrocephalus*, *Pseudorca crassidens*, *Stenella attenuata*, *S. coeruleoalba*, *S. longirostris*, *Steno bredanensis*, *Tursiops truncatus*, and *Ziphius cavirostris*; the pinniped species *Arctocephalus townsendi*, *Callorhinus ursinus*, *Mirounga angustirostris*, and *Neomonachus schauinslandi*; the seabirds *Pterodroma sandwichensis*, *Phoebastria albatrus*, *Puffinus auricularis newelli*, and *Oceanodroma castro*; the sea turtle species *Caretta caretta*, *Chelonia mydas*, *Dermochelys coriacea*, *Eretmochelys* *imbricata*, and *Lepidochelys olivacea*; the fish species *Alopias superciliosus*, *Carcharhinus longimanus*, *Manta alfredi*, *birostris*, *Sphyrna lewini*, and *Thunnus orientalis*; the coral species *Acanthastrea brevis*, *Acropora aculeus*, *A. aspera*, *A. dendrum*, *A. listeri*, *A. speciosa*, *A. tenella*, *Alveopora verrilliana*, *Leptoseris incrustans*, *Montipora caliculata*, *Pavona cactus*, *P. decussata*, *Turbinaria mesenterina*, and *T. stellulata*; and the mollusk species *Pinctada margaritifera* and *Tridacna gigas*.

Based on our conclusion that the proposed action may affect but is not likely to adversely affect nesting sea turtle or listed bird species, the USASMDC/ARSTRAT and USAF/LCMC requests U.S. Fish and Wildlife Services concurrence for our may affect but not likely to adversely affect determination for these species.

I am also providing copies of this letter and the BA to Ms. Moriana Phillip, Republic of the Marshall Islands Environmental Protection Authority; Dr. Steven Kolinski, National Marine Fisheries; Helene Takemoto, U.S. Army Corp of Engineers; and Mr John McCarrol, U.S. Environmental Protection Agency.

Please contact Mark Hubbs, USASMDC/ARSTRAT, Environmental Division, regarding this consultation request at (256) 955-2608 or mark.e.hubbs.civ@mail.mil.

Sincerely,

David Hasley
Chief, Environmental Division
U.S. Army Space and Missile Defense
Command/ Army Forces Strategic
Command

Enclosure

United States Department of the Interior

FISH AND WILDLIFE SERVICE

Pacific Islands Fish and Wildlife Office
300 Ala Moana Boulevard, Room 3-122
Honolulu, Hawaii 96850

Mark Hubbs
Environmental Engineer
U.S. Army Space and Missile Defense Command/
Army Forces Strategic Command (USASMDC/ARSTRAT)
PO Box 1500
Huntsville, AL 35807-3801

March 18, 2019

Dear Mr. Hubbs:

The U.S. Fish and Wildlife Service (Service) received your request for comments dated December 12, 2018 for a Notice of Proposed Action (NPA) for four test flights of the Air-Launched Rapid Response Weapon (ARRW). In addition, we received your biological assessment and request for concurrence on the consultation of four species of birds (*Pterodroma sandwichensis*, *Phoebastria albatrus*, *Puffinus auricularis newelli*, and *Oceanodroma castro*) and five species of sea turtles (*Caretta caretta*, *Chelonia mydas*, *Dermochelys coriacea*, *Eretmochelys imbricata*, and *Lepidochelys olivacea*). The NPA includes up to four impacts within 2 years associated with the ARRW testing to demonstrate and collect data on key technologies, such as thermal control, precision navigation, guidance, control, and enabling capabilities of the ARRW vehicle and development payload during hypersonic flight.

NPA comments:

The discussion in the BA only discusses consultation species, and does not address coordination species including marine species and birds protected under the Migratory Bird Treaty Act (MBTA) and the USAKA Environmental Standards (UES). There is legal uncertainty as to the culpability of unintentional take of MBTA species, and US Federal Courts are divided in their assessment of criminality regarding such unintentional take. The UES, however, require protection of coordination species during mission activities, and consideration should thus be given to protecting these species. We therefore recommend that USASMDC also implement the coordination procedures of the UES (Section 3-4.6) in addition to the consultation procedures.

Marine Resources

The marine resources covered under the coordination procedures include all corals (black coral, stony corals, organ-pipe corals, fire corals, and lace corals) as well as the giant clam (*Tridacna maxima*), the conchs (*Lambis lambis, Lambis scorpius, and Lambis truncata*), the fish (*Plectropomus laevis* and *Epinephelus lanoceolatus*), the coconut crab (*Birgus latro*), and the sea grass (*Halophila gaudichaudii*). There is a high likelihood some of these species will be present within the vicinity of Illeginni. This analysis can be conducted under the coordination procedures of Section 3-4.6.

The Service recommends that controls to be developed for impacts to marine species and reef habitats, including appropriate response measures to be implemented in the case of an unintentional direct impact to marine resources. These measures should include prompt notification to the Appropriate Agencies and a marine resource impact assessment so that restoration actions can be considered.

Terrestrial Resources

The most vulnerable seabird species at Illeginni is the ground-nesting Black-naped Tern (BNTE; *Sterna sumatrana*), which nests within the targeted impact area near the helicopter pad on Illeginni Islet. Black-naped terns nest during most months of the year, and eggs or chicks may be present in the targeted impact area at any time of the year. Any active nests, eggs and chicks would likely be killed or injured by direct contact or ejected debris. The number of nests observed by USFWS on Illeginni has not exceeded three or four in any given seabird survey, and BNTE normally have one or two viable eggs or chicks. Locations of BNTE nests on Illeginni during the 2016 biological survey conducted by the Service are shown in Figure 1.

Figure 1: BNTE nests and chicks located by USFWS in 2014 on Illeginni Islet.

The maximum number of adversely affected BNTE should not exceed 12 birds (4 adults and 8 eggs or chicks) if impact of the reentry vehicle (RV) is during daylight hours, when one adult of each pair is over the open ocean foraging for small fish. A maximum of 16 birds could be injured or killed if the impact is at night when both adults are roosting at or near the nests. It is probable that support activities near the helicopter pad on Illeginni will deter some terns from initiating nests before launch, but terns incubating eggs or feeding chicks will attempt to continue nesting throughout the activities. Nests and young chicks can be protected with the construction of wooden "A-frame" structures as shown in Figure 2, which will serve to shade the eggs and chicks if adults are flushed from the nest and will provide warning to support personnel to avoid the nests. The A-frames could be painted orange or another highly visible color to serve as a warning to personnel to avoid the nests. Terns may abandon the A-frames, but this may be unavoidable, and will provide the maximum protection of birds and eggs during ARRW activities.

Figure 2. Tern nesting beneath an A-frame shelter in Massachusetts.

We recommend that KRS Environmental Services search the area for nests and chicks prior to any equipment mobilization and cover nests with A-frames. We recommend monitoring the area during pre-launch activities to insure no nests are disturbed. Sturdy A-frames could also protect some nests and eggs from small ejected debris at impact, depending on their distance from the impact crater.

Great Crested Terns (*Thalasseus bergii*) may also nest on Illeginni, but the Service has no positive data to report in regard to where or when the great crested terns might breed. They nest on sand spits, and the most likely area would be the spit to the northwest of Illeginni Islet.

All the terrestrial and seabirds on Illeginni will likely exhibit startle reflexes when a payload RV impacts the island, but the startle reflex will not likely adversely affect any birds. Black noddies (*Anous minutus*) actively incubating eggs on nests in *Pisonia* trees several hundred meters to the south will briefly leave the nests, but the startle reflex should not cause any eggs or chicks to fall from the nest. The sound pressures of the sonic boom and impact may cause a temporary threshold shift (TTS) in the hearing of birds at a distance (uncertain distance) from the impact, and may cause a prolonged, but temporary, non-lethal threshold shift in the hearing of birds near the impact area. All bird species studied have healing mechanisms to regenerate damaged auditory tissues and prevent permanent hearing impairment (Dooling et al 1997, Smolders 1999). These sound pressure effects would not have a significant effect on local populations.

Potential Adverse Affect

The BA analysis of possible effects to Newell's shearwater (*Puffinus auricularis newelli*), band-rumped stormpetrel (*Oceanodroma castro*), short-tailed albatross (*Phoebastria albatrus*), and Hawaiian petrel (*Pterodroma sandwichensis*) are explained and demonstrate very unlikely effects to individual birds. In the event that a listed seabird was in the splashdown area of the broad ocean area (BOA), the bird would probably exhibit a startle reflex, which would not likely adversely affect the individual. Similarly, the possibility of direct contact with a listed seabird is remote. Within the impact area, we consider the only sea turtles potentially present to be the Green (*Chelonia mydas*) and Hawksbill (*Eretmochelys imbricata*). The others (*Caretta caretta*, *Dermochelys coriacea*, and *Lepidochelys olivacea*) have not been sighted around or on Illeginni and would therefore would not likely sustain any adverse affect.

Conservation Measures

The following conservation measures are provided based on the information contained within the January 29, 2019 BA as well as the previous consultation for the U.S. Navy Strategic Systems Programs' Flight Experiment-1 (FE-1) on Green and Hawksbill sea turtles and Newell's Shearwater. The following avoidance and minimization measures are considered part of the project description:

- If personnel observe sea turtles in or near potential impact zones, sightings will be reported to appropriate test and USAG-KA personnel for consideration in launch planning.
- Vessel and equipment operations will not involve any intentional discharges of fuel, toxic waters, or plastics and other solid wastes that could harm terrestrial or marine life.
- Hazardous materials will be handled in adherence to the hazardous materials and waste management systems of USAG-KA. Hazardous waste incidents will comply with the emergency procedures set out in the Kwajalein Environmental Emergency Plan (KEEP) and the UES.
- All equipment and packages shipped to USAG-KA will undergo inspection prior to shipment to prevent the introduction of alien species into Kwajalein Atoll.
- Pre-flight monitoring by qualified personnel will be conducted on Illeginni Islet for sea turtles or sea turtle nests. For at least 8 weeks preceding the test launch, Illeginni Islet will be surveyed by pre-test personnel for sea turtles, sea turtle nesting activity, and sea turtle nests on a bi-weekly basis. If possible personnel will inspect the area within two days of the launch. If sea turtles or sea turtle nests are observed near the impact area, observations will be reported to appropriate test and USAG-KA personnel for consideration in approval of the launch and to NMFS and the Service.
- Personnel will report any observations of sea turtles or sea turtle nests on Illeginni to appropriate test and USAG-KA personnel to provide to NMFS and USFWS.

- Debris recovery and site cleanup will be performed on land. Recovery and cleanup will be conducted in a manner to minimize further impacts on biological resources.
- At Illeginni Islet, should any missile components or debris impact areas of sensitive biological resources, a Service or NMFS biologist will be allowed to provide guidance and or/or assistance in recovery operations to minimize impacts on such resources.
- Although unlikely, any dead or injured marine mammals or sea turtles sighted by post-flight personnel will be reported to the USAG-KA Environmental Office and USASMDC, who will then inform NMFS and the Service. USAG-KA aircraft pilots otherwise flying in the vicinity of the impact and test support areas will also similarly report any opportunistic sightings of dead or injured marine mammals or sea turtles.
- As soon as practical following payload impact at Illeginni Islet, qualified biologists will be allowed to assist in recovering and rehabilitating any injured sea turtles found.
- During post-test recovery and cleanup, should personnel observe endangered, threatened, or other species requiring consultation moving into the area, work will be delayed until such species were out of harm's way or leave the area.
- To minimize impacts during post-flight operations, the Service and NMFS will be allowed to provide guidance and/or assistance during recovery and cleanup at Illeginni Islet. In all cases, recovery and cleanup operations will be conducted in a manner to minimize further harm to biological resources.

Summary

After reviewing the new information provided, we have concluded that the location of the target site is clear of the shoreline, however, payload impact debris and ejecta could impact adjacent sandy shoreline. While Illeginni Islet has shoreline habitat that a sea turtle could successfully lay a nest, a significant portion of the habitat is submerged or inundated during high tide events; thus drowning any sea turtle nests that may be present. In addition, any turtle nesting or terrestrial activity sign that could identify any nesting or terrestrial behaviors would be washed away if they are below the high tide line.

Based on the proposed action, information provided in your January 29, 2019 BA, and the minimization measures included within this letter, it is not probable the proposed action will impact sea turtle(s), Newell's shearwater(s) (*Puffinus auricularis newelli*), band-rumped stormpetrel(s) (*Oceanodroma castro*), short-tailed albatross(es) (*Phoebastria albatrus*), or Hawaiian petrel(s) (*Pterodroma sandwichensis*). Therefore, the Service has determined any effects are discountable and not likely to adversely affect the sea turtles (*Caretta caretta*, *Chelonia mydas*, *Dermochelys coriacea*, *Eretmochelys imbricata*, and *Lepidochelys olivacea*) and their nests and the Newell's shearwater (*Puffinus auricularis newelli*), band-rumped stormpetrel (*Oceanodroma castro*), short-tailed albatross (*Phoebastria albatrus*), or Hawaiian petrel (*Pterodroma sandwichensis*). Therefore, the Service concurs with your determination that the proposed test flight may effect, but is not likely to adversely affect the sea turtles (*Caretta caretta*, *Chelonia mydas*, *Dermochelys coriacea*, *Eretmochelys imbricata*, and *Lepidochelys olivacea*) and their nests and the Newell's shearwater (*Puffinus auricularis newelli*), band-rumped stormpetrel

(*Oceanodroma castro*), short-tailed albatross (*Phoebastria albatrus*), or Hawaiian petrel (*Pterodroma sandwichensis*).

Unless the project description changes, or new information reveals that the proposed project may affect listed species in a manner or to an extent not considered, or a new species or critical habitat is designated that may be affected by the proposed action, no further action pursuant to Section 3-4.5 of the UES and Section of the ESA is necessary.

We appreciate the opportunity to provide input on this NPA. If you have questions regarding our comments, please contact Aquatic Ecosystem Conservation program manager Dan Polhemus (dan_polhemus@fws.gov or 808-792-9400). For specific comments on terrestrial resources, please contact Environmental Toxicologist Michael Fry (michael_fry@fws.gov or 808-792-9461). For specific comments on marine resoures, please contact Marine Biologist Tony Montgomery (tony_montgomery@fws.gov or 808-792-9456.

References:

Doolling RJ, Ryals BM, and K Manabe. 1997 Recovery of hearing and vocal behavior after hair-cell regeneration . PNAS 94: 14206-14210.

Smolders JWT. 1999. Functional recovery in the Avian Ear after Hair-Cell Regeneration. Audiol. Neurootol. 4: 286-302.

Sincerely,

Dan Polhemus
Aquatic Ecosystem Conservation Program

DEPARTMENT OF THE ARMY
U.S. ARMY SPACE AND MISSILE DEFENSE COMMAND/
ARMY FORCES STRATEGIC COMMAND
POST OFFICE BOX 1500
HUNTSVILLE, ALABAMA 35807-3801

REPLY TO
ATTENTION OF

January 31, 2019

Steve Kolinski, PhD
National Marine Fisheries Service
Pacific Islands Regional Office
1845 Wasp Boulevard, Building 176
Honolulu, HI 96818

Dear Dr. Kolinski,

The U.S. Army Space and Missile Defense Command / Army Forces Strategic Command (USASMDC/ARSTRAT) is assisting the U.S. Air Force Life Cycle Management Center (USAF/ LCMC), the action proponent, in evaluating the effects of flight tests of the Air-launched Rapid Response Weapon (ARRW). We have prepared a Biological Assessment (BA) to initiate formal consultation under Section 3-4.5 of the U. S. Army Kwajalein Atoll Environmental Standards (UES), Section 7 (a)(2) of the U.S. Endangered Species Act (ESA), and in connection with Section 101 of the Marine Mammal Protection Act (MMPA). There is no affected critical habitat for any of the protected species in the proposed action area.

As described in the enclosed BA, UES, ESA, and MMPA protected species occur or have the potential to occur in the action area. Based on analyses of all of the potential stressors resulting from the proposed action, we have concluded that the proposed action may affect and is likely to adversely affect some of these species. These include one fish species, *Cheilinus undulatus*; three mollusk species, *Hippopus hippopus*, *Tectus niloticus*, and *Tridacna squamosa*; and seven coral species, *Acropora microclados*, *A. polystoma*, *Cyphastrea agassizi*, *Heliopora coerulea*, *Pavona venosa*, *Pocillopora meandrina*, and *Turbinaria reniformis*.

We have concluded that the proposed action may affect but is not likely to adversely affect 29 cetacean species, 4 pinniped species, 4 seabird species, 5 sea turtle species, 6 fish species, 15 coral species, 2 mollusk species, and larval fish, coral, and mollusks. These species include the cetacean species *Balaenoptera acutorostrata*, *B. boralis*, *B. edeni*, *B. musculus*, *B. physalus*, *Delphinus delphis*, *Feresa attenuata*, *Globicephala macrorhynchus*, *Grampus griseus*, *Indopacetus pacificus*, *Kogia breviceps*, *K. sima*, *Lagenodelphis hosei*, *Lissodelphis borealis*, *Megaptera novaeangliae*, *Mesoplodon carlhubbsi*, *M. densirostris*, *M. ginkgodens*, *Orcinus orca*, *Peponocephala electra*, *Phocoenoides dalli*, *Physeter macrocephalus*, *Pseudorca crassidens*, *Stenella attenuata*, *S. coeruleoalba*, *S. longirostris*, *Steno bredanensis*, *Tursiops truncatus*, and *Ziphius cavirostris*; the pinniped species *Arctocephalus townsendi*, *Callorhinus ursinus*, *Mirounga angustirostris*, and *Neomonachus schauinslandi*; the seabirds *Pterodroma sandwichensis*, *Phoebastria albatrus*, *Puffinus auricularis newelli*, and *Oceanodroma castro*; the sea turtle species *Caretta caretta*, *C helonia mydas*, *Dermochelys coriacea*, *Eretmochelys imbricata*, and *Lepidochelys olivacea*; the fish species *Alopias superciliosus*, *Carcharhinus longimanus*, *Manta alfredi*, *birostris*, *Sphyrna lewini*, and *Thunnus orientalis*; the coral species

Acanthastrea brevis, *Acropora aculeus*, *A. aspera*, *A. dendrum*, *A. listeri*, *A. speciosa*, *A. tenella*, *Alveopora verrilliana*, *Leptoseris incrustans*, *Montipora caliculata*, *Pavona cactus*, *P. decussata*, *Turbinaria mesenterina*, and *T. stellulata*; and the mollusk species *Pinctada margaritifera* and *Tridacna gigas*.

Because of these potential effects to UES, ESA, and MMPA protected species, the USASMDC/ARSTRAT and USAF/LCMC would like to initiate formal consultation with the National Oceanic and Atmospheric Administration, National Marine Fisheries Service under section 3-4.5 of the UES for potential effects in the Republic of the Marshall Islands to *Cheilinus undulatus*, *Hippopus hippopus*, *Tectus niloticus*, *Tridacna squamosa*, *Acropora microclados*, *A. polystoma*, *Cyphastrea agassizi*, *Heliopora coerulea*, *Pavona venosa*, *Pocillopora meandrina*, and *Turbinaria reniformis*.

I am also providing copies of this letter and the BA to Ms. Moriana Phillip, Republic of the Marshall Islands Environmental Protection Authority; Dr. Dan Polemous, U.S. Fish and Wildlife Service; Helene Takemoto, U.S. Army Corp of Engineers; and Mr John McCarrol, U. S. Environmental Protection Agency.

Please contact Mark Hubbs, USASMDC/ARSTRAT, Environmental Division, regarding this consultation request at (256) 955-2608 or mark.e.hubbs.civ@mail.mil.

Sincerely,

David Hasley
Chief, Environmental Division
U.S. Army Space and Missile Defense
Command/ Army Forces Strategic
Command

Enclosure

B

Agencies, Organizations and Repositories Notified of Notice of Availability

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APPENDIX B
Agencies, Organizations and Repositories Notified of Notice of Availability

The following agencies, organizations and repositories received the Notice of Availability:

The Kwajalein Hourglass (U.S. Army Garrison Kwajalein Atoll [USAG-KA])

The Marshall Islands Journal

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C

Final
Biological Opinion

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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
Consulting Agency:	National Marine Fisheries Service, Pacific Islands Region
NMFS File No. (PCTS):	PIR-2019-00639
PIRO Reference No.:	I-PI-19-1751-AG
Approved By:	TOSATTO.MICHAEL.D.1014020922 Digitally signed by TOSATTO.MICHAEL.D.1014020922 Date: 2019.07.30 12:24:03 -10'00'
	Michael D. Tosatto Regional Administrator, Pacific Islands Region
Date Issued:	07 – 30 - 2019

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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

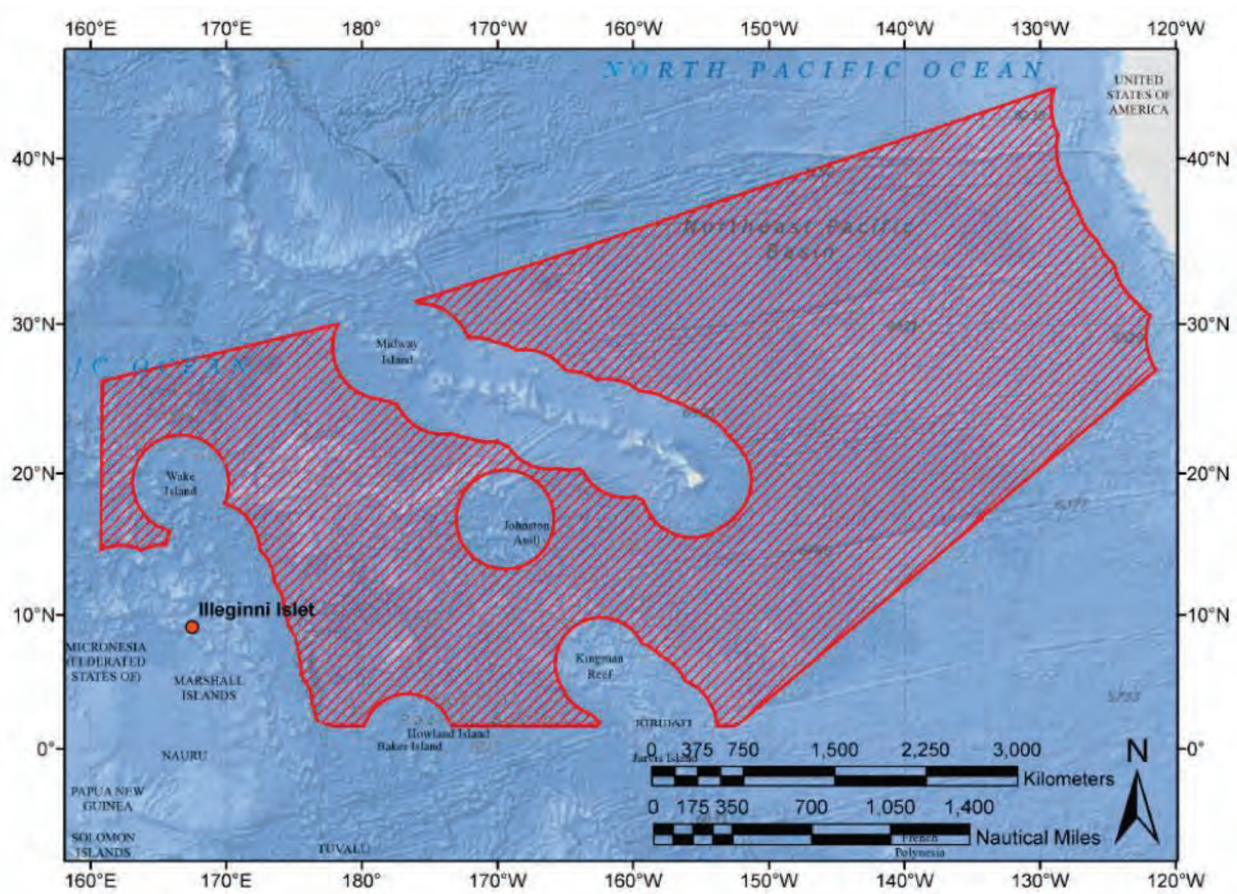

Figure 1. The Broad Ocean Area portion of the action area.

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.

<u>Sensor Coverage in the BOA:</u> 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.

<u>Sensor Coverage at USAKA:</u> 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.

<u>Pre-Flight Preparation at Illeginni Islet</u>: 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.

<u>Flight Operations</u>: 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 overestimates 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. [redacted] 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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