Biological Assessment for Ground Based Strategic Defense Test Program Activities at Kwajalein Atoll

Prepared for:

U.S. Air Force Nuclear Weapons Center
Kirtland Air Force Base, New Mexico

and

U.S. Army Space and Missile Defense Command
Huntsville, Alabama

Prepared by:

KFS, LLC
Huntsville, Alabama

Final
5 November 2020

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ACRONYMS AND ABBREVIATIONS

μPa	micropascal(s)
Al_2O_3	aluminum hydroxide
ARSTRAT	Army Forces Strategic Command
BA	Biological Assessment
Be	beryllium
BO	Biological Opinion
cm	centimeter(s)
CO_2	carbon dioxide
dB	decibels
DEP	Document of Environmental Protection
DoD	Department of Defense
DU	depleted uranium
ESA	Endangered Species Act
FAO	Food and Agriculture Organization of the United Nations
FE-2	Flight Experiment-2
FR	Federal Register
ft	foot/feet
FY	Fiscal Year
GBSD	Ground Based Strategic Deterrent
HAFB	Hill Air Force Base
HCl	hydrochloric acid
ICBM	Intercontinental Ballistic Missile
km	kilometer(s)
km^2	square kilometer(s)
KMISS	Kwajalein Missile Impact Scoring System
LF	Launch Facility
LLNL	Lawrence Livermore National Laboratory
m	meter(s)
m^2	square meter(s)
MIMRA	Marshall Islands Marine Resource Authority
MMIII	Minuteman III

MMPA	Marine Mammal Protection Act
nm	nautical mile(s)
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
PBO	Programmatic Biological Opinion
PIRO	Pacific Islands Regional Office
PTS	permanent threshold shift
re	referenced to
RMI	Republic of the Marshall Islands
RTS	Ronald Reagan Ballistic Missile Defense Test Site
RV	Reentry Vehicle
TTS	temporary threshold shift
U.S.	United States
UES	United States Army Kwajalein Atoll Environmental Standards
USAF	United States Air Force
USAG-KA	United States Army Garrison – Kwajalein Atoll
USASMDC	United States Army Space and Missile Defense Command
USC	United States Code
USFWS	United States Fish and Wildlife Service
VAFB	Vandenberg Air Force Base
yd^2	square yard(s)

1.0 INTRODUCTION

1.1 Purpose and Objectives

The purpose of this Biological Assessment (BA) is to evaluate the potential effects of the proposed Ground Based Strategic Deterrent (GBSD) Test Program (Proposed Action) on species listed under the United States Army Kwajalein Atoll Environmental Standards (UES), and on designated critical habitat at Kwajalein Atoll, Republic of the Marshall Islands (RMI). The United States Air Force (USAF) has prepared this BA in accordance with the requirements of Section 7 of the Endangered Species Act (ESA) and Section 3-4 of the UES with support from the U.S. Army Space and Missile Defense Command (USASMDC).

GBSD represents the modernization of the land-based nuclear arsenal and would eventually replacing the aging Minuteman III (MMIII) weapon system. Developed using 1960s technology and materials, the MMIII weapon system has exceeded its designed life expectancy. While the system remains an active, viable deterrent for the United States, many components are becoming obsolete and unsupportable, resulting in continual upgrades to maintain system reliability and performance. It is in the best interest of national security to replace the MMIII weapon system. However, before the USAF can make future decisions to remove the MMIII weapon system from active status and deploy the new GBSD weapon system, system development and testing under the proposed GBSD Test Program must first occur. The Proposed Action would implement booster development and flight testing of the proposed GBSD weapon system. The purpose of this testing is to assess attainment of technical design parameters; verify and validate system performance capabilities (baseline requirements); and determine whether the system is operationally effective, survivable, and safe for its intended use.

The proposed GBSD Test Program involves the development and testing of a new Intercontinental Ballistic Missile (ICBM) weapon system that would eventually replace the aging MMIII weapon system. Implementation of the test program would include facility construction or modifications at Hill Air Force Base (HAFB), Vandenberg Air Force Base (VAFB), and Dugway Proving Ground. In addition, GBSD flight test activities would be conducted from VAFB and include target impacts at United States Army Garrison – Kwajalein Atoll (USAG-KA) sites in the RMI. Because deployment of the new GBSD weapon system cannot occur until it has been adequately tested and proven sufficiently mature for operational use, both GBSD and MMIII flight test activities and related operations would overlap at HAFB, VAFB, and USAG-KA. Such testing would overlap for up to 10 years or until decisions are made to remove the MMIII weapon system from active status.

1.2 Regulatory Setting

This BA addresses the potential effects of Proposed Action activities at Kwajalein Atoll on UES consultation species in compliance with Section 3-4 of the UES. For the portions of the Proposed Action that would take place in and over U.S. territory, a separate BA has been prepared to comply with requirements under Section 7 of the ESA where necessary. This assessment addresses only the portions of the Proposed Action in and over RMI territory, including territorial waters. Since Section 3-4 of the UES is derived primarily from the regulations implementing the ESA and the UES is intended to provide substantially similar environmental protections at the ESA (NMFS 2019), the regulatory setting of the ESA is also described in this section.

United States Army Kwajalein Atoll Environmental Standards (UES). The Compact of Free Association between the RMI and the United States (48 United States Code [USC] Section [§] 1921) requires all U.S. Government activities at USAG-KA and all Department of Defense (DoD) and Ronald Reagan Ballistic Missile Defense Test Site (RTS) activities in the RMI to conform to specific compliance requirements, coordination procedures, and environmental standards identified in the UES (USASMDC/ARSTRAT 2018). As specified in Section 2-2 of the UES, these standards also apply to all activities occurring in the territorial waters of the RMI. The Proposed 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).

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

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

Endangered Species Act (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. Under Section 9 of the ESA it is unlawful for any person subject to the jurisdiction of the United States to take ESA listed species within the United States or territorial sea of the United States. As defined in the ESA, the term “take” means to harass, harm, pursue, hunt, wound, kill, trap, capture, or collect an ESA listed species (16 USC §§ 1532, 1538). 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.

Section 7(a)(2) of the ESA requires federal agency cooperation and consultation with the USFWS and/or NMFS to ensure that any federal action, including federal permits or funding, is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of their critical habitat (16 USC §§ 1536).

Destruction or adverse modification of designated critical habitat means a direct or indirect alteration that appreciably diminishes the value of critical habitat for the conservation of a listed species (81 Federal Register [FR] 7214 [11 February 2016]). Alterations of critical habitat may include, but are not limited to, those that alter the physical or biological features essential to the conservation of a species or that preclude or significantly delay development of such features (81 FR 7214 [11 February 2016]). Destruction or adverse modification of critical habitat is determined on the basis of whether implementation of the proposed federal action would result in alteration of the quantity or quality of the essential physical or biological features of designated critical habitat, or would preclude or significantly delay the capacity of that habitat to develop those features over time, and if the effect of the alteration was to appreciably diminish the value of critical habitat for the conservation of the species (81 FR 7214 [11 February 2016]).

1.3 Consultation History

Early coordination and pre-consultation with NMFS and USFWS for the Proposed Action was conducted during a series of meetings, phone conversations, and email communications including:

- 23 July 2020 – USASMDC and KFS, LLC personnel met with Steve Kolinski, Ron Dean, Josh Rudolph, and Bonnie Shorin of NMFS Pacific Islands Regional Office (PIRO) to provide NMFS with general information about the GBSD Test Program project and to discuss a consultation plan for the Proposed Action. During this meeting, parties discussed the similarity of the Proposed Action activities to those evaluated for the MMIII Fuze Modernization Program.

- 25 August 2020 – USASMDC and KFS, LLC personnel met with Dan Polhemus, Michael Fry, and Jeremy Rynal of USFWS Pacific Islands Fish and Wildlife Office to provide USFWS with general information about the GBSD Test Program project and to discuss a consultation plan for the Proposed Action. During this meeting, USFWS personnel requested that the Pacific Islands Fish and Wildlife Office conduct the required consultations under the UES for proposed activities at Kwajalein Atoll and that any necessary consultation under the ESA for portions of the Proposed Action at VAFB be conducted with the USFWS Pacific Southwest Regional Office.

1.3.1 Interrelated and Interdependent Activities

The consultation history below includes activities interrelated and interdependent to those addressed in this BA as well as justification for why consultation is not required for some of these activities. Because the proposed GBSD activities and MMIII activities are interrelated and because the activities for the two actions are very similar, consultation history for the MMIII action is included in the consultation history that follows.

Infrastructure Development at HAFB and Dugway Proving Ground. The proposed infrastructure development which would occur at HAFB and Dugway Proving Ground would have no effect on federally listed species or designated critical habitats. No ESA listed threatened, endangered, or candidate species or designated critical habitats are known to occur on HAFB (USAF 2016). At Dugway Proving Ground, three sites are being considered for construction of a 1-acre testing facility. No ESA listed threatened, endangered, or candidate species or designated critical habitats are known to occur at or near any of the proposed GBSD Test Program sites on Dugway Proving Ground (U.S. Army 2016, U.S. Army 2020).

Launch Activities at VAFB. In coordination with the VAFB Natural Resources Management (USAF, 30th Space Wing Civil Engineer Squadron, Installation Management Flight, Natural Resources Management), the USAF and USASMDC have concluded that all Proposed Action launch activities at VAFB are covered under existing programmatic consultations for ongoing launch activities at VAFB and that no further consultation is needed for Proposed Action launch activities. A brief Section 7 consultation history for ongoing programmatic launch activities at VAFB is provided below for ESA-listed species and designated critical habitats under the jurisdiction of both NMFS and USFWS.

Consultation history with NMFS for VAFB launch activities included the following:

- In 2015, the USAF determined that MMIII launch activities would have no effect on ESA listed species under NMFS jurisdiction at VAFB (USAF 2020b, NMFS 2015a).
- The USAF has concluded that the Proposed Action launch activities would have no effect on ESA-listed species or designated critical habitats at VAFB and that no consultation with NMFS is required for launch activities at VAFB. Guadalupe fur seals (*Arctocephalus townsendi*) are not likely to occur in the Action Area at VAFB, and no

part of the Proposed Action would affect designated critical habitat for black abalone (*Haliotus cracherodii*) or leatherback sea turtles (*Dermochelys coriacea*).

Consultation history with the USFWS for VAFB launch activities included the following:

- The Programmatic Biological Opinion (PBO) on Routine Mission Operations and Maintenance Activities at VAFB (USFWS 2018, USFWS 2015) addresses USAF actions at VAFB in five core programs: Mission Operations, Infrastructure Support, Infrastructure Development, Environmental Management, and Fire Management). These programs include firebreak management and launch-related activities under the MMIII program at Launch Facility (LF)-04, LF-09, LF-10, and LF-26, and Minotaur IV Lite (or similar vehicle) at Test Pad-01. The PBO evaluated the impact of these programs on threatened and endangered species and supersedes previous consultations that contained similar actions to those that were analyzed in the PBO.
- The Proposed Action would modernize the aging MMIII system, and flight testing would be the same or similar to that used for MMIII flight testing. The USAF would implement measures identified in the USFWS's PBO for Proposed Action launch activities and operations at VAFB. The USAF has therefore determined that GBSD flight test related impacts, firebreak maintenance, and facility maintenance at VAFB are covered under the existing PBO (USFWS 2018).

Pacific Ocean Activities. The MMIII flight tests included missile flight over the central Pacific Ocean from VAFB to Kwajalein Atoll. Consultation history with NMFS for MMIII activities in the broad Pacific Ocean included the following:

- The USAF consulted with NMFS for MMIII activities in or over the Pacific Ocean beginning approximately 46 kilometers (km; 26 nautical miles [nm]) offshore from VAFB and extending to Kwajalein Atoll (NMFS 2015a). In their 2015 BO (NMFS File No. PIRO-2015-9650), NMFS determined that MMIII activities in the over-ocean flight corridor (including elevated noise levels, falling missile components, and exposure to hazardous materials) may affect but was not likely to adversely affect ESA-listed marine mammals, sea turtles, or fish (NMFS 2015a). NMFS concluded that effects would be insignificant or discountable for these species in the over-ocean flight corridor (NMFS 2015a). NMFS also concluded that the MMIII action would have no effect on critical habitats designated under the ESA with the exception that they determined the action may affect but was not likely to adversely affect critical habitat for Hawaiian monk seals (*Neomonachus schauinslandi*) and for leatherback sea turtles (NMFS 2015a).

For the Proposed Action, each GBSD test vehicle would continue flight downrange to a target location after launch from VAFB. To comply with GBSD Test Program security classification requirements regarding missile flight paths and downrange testing, only GBSD downrange target locations at USAG-KA are addressed in the GBSD Environmental Assessment/ Overseas Environmental Assessment (USAF 2020a). Other downrange actions and locations are described and their potential effects on ESA-listed species analyzed in a separate, classified annex to the GBSD Environmental Assessment/Overseas Environmental Assessment.

Activities at Kwajalein Atoll. The proposed GBSD test program activities at Kwajalein Atoll would be very similar to other recent flight tests with terminal payload impacts at Illeginni Islet including MMIII tests (USAF 2020b).

Consultation history with NMFS for MMIII activities included:

- In 2015, the USAF consulted with NMFS on the effects of MMIII Modification activities on UES-listed consultation species in the Action Area. On 29 July 2015, NMFS PIRO issued a BO for MMIII activities that included up to five tests per year with Reentry Vehicle (RV) impacts on land at Illeginni Islet (NMFS File Number: PIRO-2015-9650) (NMFS 2015a). In this BO, NMFS concluded that the proposed MMIII action was not likely to adversely affect 43 consultation species and would have no effect on critical habitats designated in the RMI (NMFS 2015a). NMFS concluded that the debris and ejecta from crater formation were likely to adversely affect 15 UES-consultation coral species and top shell snails (*Tectus niloticus*) but that the anticipated loss of individuals due to the MMIII action was not likely to result in the jeopardy of any of these UES consultation species (NMFS 2015a).
- After NMFS issued the 2015 BO for the MMIII Modification action, the USAF changed the location of proposed RV impacts and additional species were listed as consultation species under the UES. The USAF removed Illeginni Islet land impact from the MMIII action and proposed RV impacts in the Kwajalein Missile Impact Scoring System (KMISS) and nearby deep ocean waters east of Gagan Islet only. Therefore, the USAF revised their effect determinations for the MMIII Modification action, concluding that the action was not likely to adversely affect UES consultation species in the Action Area. On 17 April 2019 NMFS amended the 2015 consultation and concurred with the USAF determination that the MMIII Modification project, with up to five tests per year between fiscal year (FY) 2019 and 2022 and four tests per year through 2030, may affect but would not likely adversely affect ESA or UES listed consultation species.

Consultation history with USFWS for MMIII activities included:

- In 2004, the USAF consulted with the USFWS Pacific Islands Fish and Wildlife Office on the effects of MMIII activities on green sea turtles (*Chelonia mydas*) and sea turtle nesting habitat on Illeginni Islet. As part of the MMIII action, the USAF proposed several avoidance and minimization measures to reduce impacts to sea turtles and sea turtle nesting habitat on Illeginni Islet. USFWS issued a BO for MMIII test activities in January 2005 (Consultation No. PN-04-246) in which the service concluded that the MMIII activities at Illeginni Islet were likely to adversely affect green turtles through reductions in breeding success or through loss of nests, eggs, or hatchlings (USFWS 2005). USFWS concluded the action was not likely to jeopardize the continued existence of green turtles and included terms and conditions related to minimization, monitoring, and reporting (USFWS 2005).

- In 2015, the USAF coordinated with the USFWS regarding MMIII Modification test activities through 2030. The USAF did not reinitiate consultation for terrestrial impacts on green turtles but decided to abide by the 2005 USFWS BO through 2030 with any effects of the MMIII Modification action being covered under that BO (USAF 2020b).
- Although the USAF is no longer targeting land on Illeginni Islet for continuing MMIII activities, the USAF decided to continue to abide by the terms of the 2005 BO (USAF 2020b).

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2.0 DESCRIPTION OF THE ACTION AREA AND PROPOSED ACTION

The Proposed Action involves developmental flight tests for the GBSD Test Program launched from VAFB with payload impact on Illeginni Islet, in the vicinity of Illeginni Islet, and in the KMISS area in the RMI (**Figure 2-1**). As discussed in the *Purpose and Objectives* (**Section 1.1**) and *Regulatory Setting* (**Section 1.2**) sections, this BA addresses only the portions of the Proposed Action taking place in or above RMI territory. The following section describes the GBSD Action Area and Proposed Action in general but focuses on the portions relevant to activities at Kwajalein Atoll. This section describes the Action Area, the Proposed Action, environmental stressors associated with the Proposed Action at Kwajalein Atoll, and avoidance and minimization measures which would be implemented as part of the Proposed Action.

2.1 Description of the Action Area

The Action Area for this BA is the terminal end of GBSD test flights within RMI territory, including the RV impact sites at Illeginni Islet, in the vicinity of Illeginni Islet, and in the KMISS area (**Figure 2-1**).

The GBSD launch vehicle would launch from VAFB, California and would likely consist of a 3-stage booster system and an experimental payload. To comply with GBSD Test Program security classification requirements regarding missile flight paths and downrange testing, only GBSD downrange target locations at USAG-KA are described and analyzed in this BA. Other downrange actions and locations are described and analyzed in a separate, classified annex to the GBSD Test Program Environmental Assessment / Overseas Environmental Assessment (USAF 2020a). The types of downrange test support activities, however, are expected to be conducted similarly to those for MMIII flight tests. GBSD spent booster motors, post boost vehicle components, and test RVs would be expected to impact primarily in ocean waters away from land areas.

The terminal end of a portion of the GBSD test flights would be at USAG-KA in the RMI with RV impact at one of three locations: (1) in ocean waters of the KMISS area, (2) in ocean waters in the vicinity of Illeginni Islet, or (3) on land at Illeginni Islet (**Figure 2-1**). Testing in the RMI would be conducted in the same manner as for the ongoing MMIII flight tests in the KMISS area (USAF 2020b), and testing on and in the vicinity of Illeginni Islet would be conducted similarly to what was previously done under the MMIII program (USAF 2004, USAF 2015). The KMISS impact area currently used for MMIII is in deep ocean waters east of Kwajalein Atoll, at least 5.6 km (3 nm) offshore of Gagan Islet. The RV impact zone in the vicinity of Illeginni Islet would be in ocean waters southwest of the islet. For MMIII testing, the test RVs were expected to typically

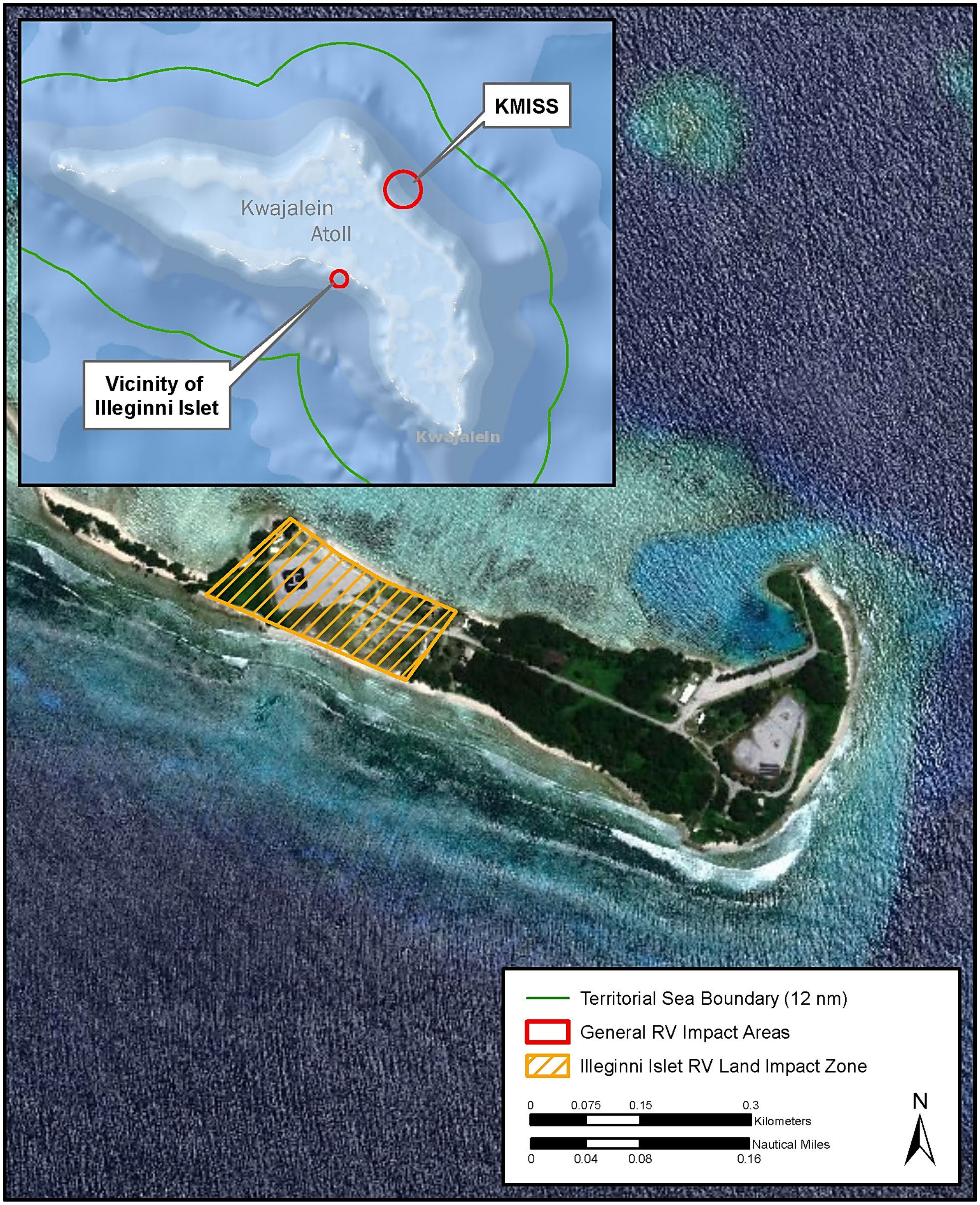


Figure 2-1. GBSD Reentry Vehicle (RV) Impact Areas at Kwajalein Atoll, Republic of the Marshall Islands.

impact up to approximately 792 meters (m; 2,600 feet [ft]) from the islet. The RV impact zone on Illeginni Islet is an area on the non-forested, northwest end of the islet that has been used for DoD testing for several decades.

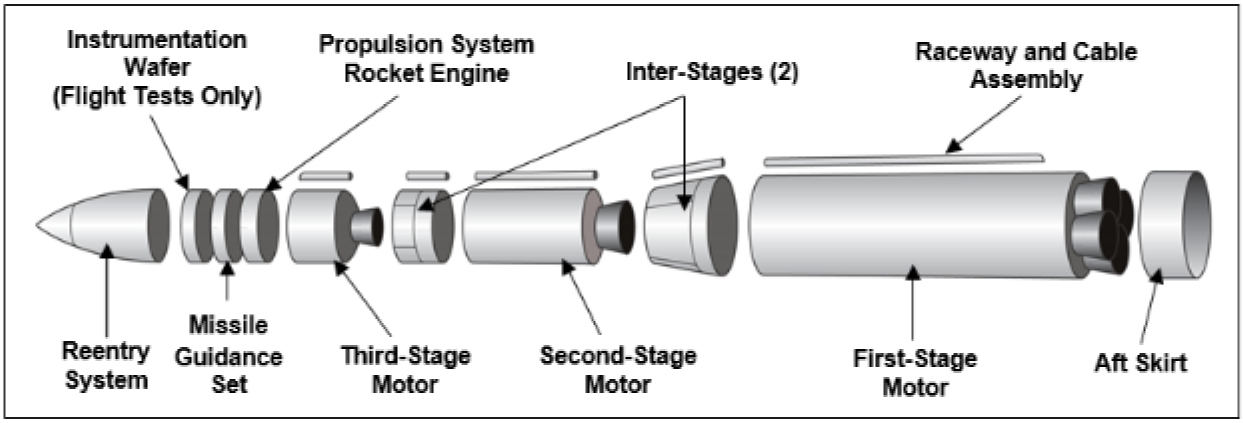
Centrally located within the RMI, USAG-KA consists of all or portions of 11 out of 93 coral islets that enclose a large lagoon. Since the late 1950s, Kwajalein Atoll has served as a primary site for flight testing ICBMs, sea-launched ballistic missiles, and antiballistic missiles. USAG-KA supports the MMIII and other flight test programs by providing tracking, sensing, and other technical and logistical support, typical of everyday operations there. An extensive array of missile tracking radars, optical sensors, and meteorological equipment are located on several of the islands. Depending on mission requirements, other auxiliary sea-based, aircraft-based, and satellite-based sensors (optical and radar systems) may be involved in tracking the missile and collecting data. Test support is provided primarily by existing Government personnel and contractors based at USAG-KA and is part of ongoing operations at USAG-KA.

2.2 Description of the Proposed Action

The proposed GBSD flight test activities analyzed in this BA consist of pre-flight preparation activities at Kwajalein Atoll, flight test activities in and above Kwajalein Atoll including RV impact, and post-flight operations at Kwajalein Atoll. The USAF proposes to conduct up to nine GBSD flight tests per year launched from VAFB starting in FY 2024 and continuing until FY 2029. A portion of these tests would involve flight termination at USAG-KA; however, since the number of tests with terminal impact at Kwajalein Atoll remains unspecified, these analyses assume that all tests could use USAG-KA. Under the GBSD Test Program, each flight test could have up to three RVs which would impact at USAG-KA. It is expected that most test RVs would be targeted at the KMISS ocean area just east of Gagan Islet, or within deep ocean waters in the vicinity of Illeginni Islet on the western side of Kwajalein Atoll (**Figure 2-1**). Such testing at the KMISS would be conducted in the same manner as for the ongoing MMIII flight tests, while testing in the vicinity of Illeginni Islet would be conducted similarly to what was previously done under the MMIII program (USAF 2004, USAF 2015). The USAF currently plans only one flight test with impact on land at Illeginni Islet for the GBSD Test Program but up to three total land RV impacts may be possible through FY 2029.

2.2.1 Launch Vehicle Description

Design of the proposed GBSD weapon system has not yet been determined, but plans are for it to be sized to fit within existing MMIII LFs at VAFB. The booster would use a solid propellant composition with similar properties to that of the MMIII booster. Like the MMIII flight test missile, the GBSD flight test missile would carry a post boost vehicle on top of the booster that includes a propulsion system rocket engine (with liquid hypergolic propellants), the missile guidance set, and a reentry system (**Figure 2-2**).



Source: USAF 2004, 2013, 2020b

Figure 2-2. Minuteman III Missile

Like the MMIII weapon system, the GBSD weapon system design also is expected to use ordnance, including motor igniter assemblies, shroud ejection motor initiator, gas generators, and a flight termination system destruct package. Should a launch anomaly occur during flight, the destruct devices, in the form of linear explosive assemblies, would separate the stages, split the motor casings, and stop forward thrust.

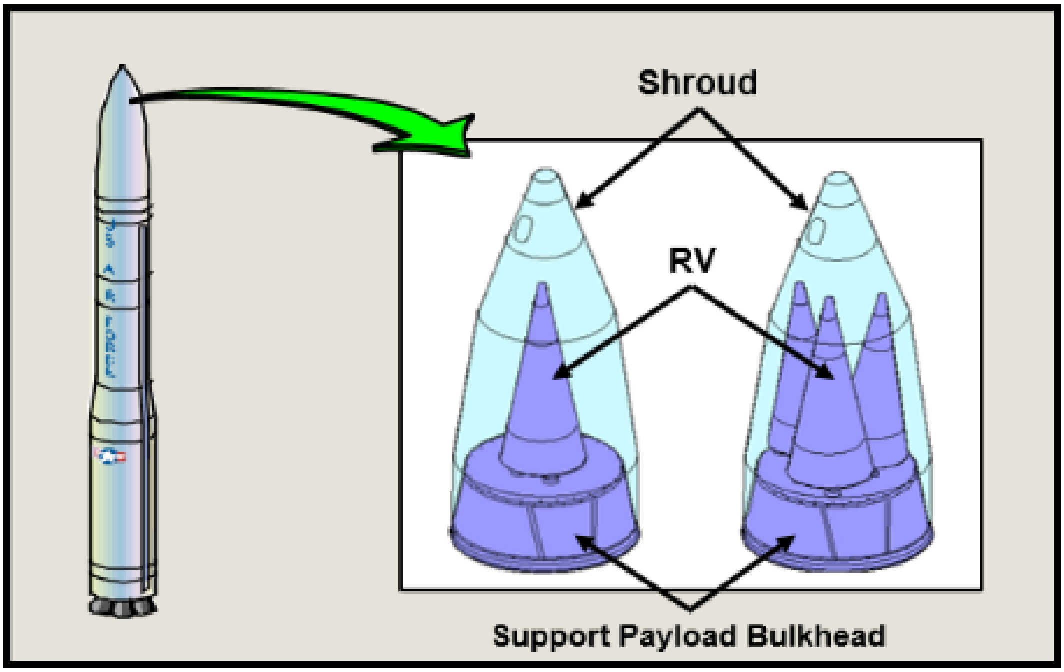
Although the GBSD reentry system (payload) may be of a new design, it would contain one to three test RVs which would be the same or similar to those used for MMIII flight testing. The MMIII reentry system was designed to contain one to three Mark 21 or Mark 12A RVs with a two-piece protective shroud (**Figure 2-3**). Test RVs are used for the annual MMIII flight tests from VAFB and the same would be expected for GBSD testing. Typical test RVs do not contain any fissile materials but do contain some hazardous materials including batteries, asbestos, depleted uranium (DU)[1], and other heavy metals (**Table 2-1**).

2.2.2 Pre-Flight Preparations at Kwajalein Atoll

Pre-flight activities would be similar to those conducted for MMIII flight tests.

For flight tests conducted at the KMISS site east of Gagan Islet, optical and electronic sensors and system support equipment are already in place on the islet and in the offshore ocean waters. Fixed underwater sensors that would score the precision of the RVs are already in place as part of the KMISS system and are a minimum of 5.5 km (3 nm) offshore at depths ranging from 1,524 to 3,658 m (5,000 to 12,000 ft) (USAF 2015).

[1] Uranium (U) is a silver-colored, radioactive metal that is nearly twice as dense as lead. Small amounts of U occur naturally in soil, water, air, plants, and animals; and contribute to natural background radiation in the environment. Depleted uranium is a byproduct of the enrichment process used to make weapons grade U-235. Depleted uranium retains the natural toxicological properties of U, but has approximately half of its radiological activity. Depleted uranium is a non-fissile material (USAF 2004).



Source: Modified from USAF 2013, 2020b

Figure 2-3. Minuteman III Reentry System

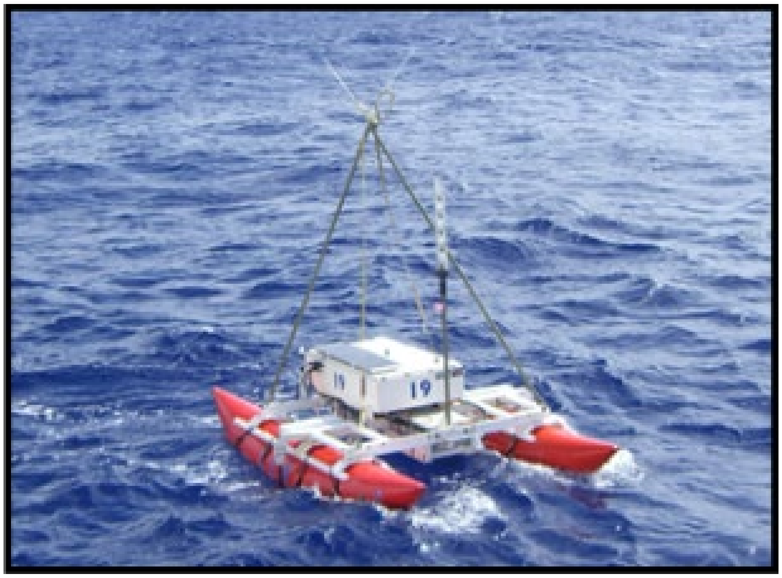
Table 2-1. MMIII Reentry Vehicle Characteristics.

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

Sources: USAF 2004, USAF 2020a, USAF 2020b

In the vicinity of Illeginni Islet, pre-flight activities would include several vessel round-trips and helicopter trips to the RV impact location for personnel and equipment transport. Up to 17 Lawrence Livermore National Laboratory (LLNL) sensor rafts stored at USAG-KA would be temporarily deployed in ocean waters near the RV impact location. The rafts measure approximately 2.7 m (9 ft) wide and 4.6 m (15 ft) long, and contain various sensors, including neutron detectors, cameras, hydrophones, and video equipment (**Figure 2-4**). The rafts generally use battery-powered trolling motors for station-keeping to ensure proper positioning for the flight tests (USAF 2020b). No anchors would be used to maintain raft positions. Rafts would be deployed from a landing craft utility or similar vessel and would be placed in waters at least 3 m (10 ft) deep.

For tests conducted at Illeginni Islet, portable camera stands would be set up on the western end of Illeginni Islet to record the flight test prior to the test. Test equipment would be transported to Illeginni Islet by barge or landing craft. It is anticipated that, similar to other flight tests with payload impact at Illeginni Islet, there would be increased human activity on Illeginni Islet over a 3-month period.



Source: USAF 2010

Figure 2-4. Representative Sensor Raft System

2.2.3 Flight Test

As previously described, the GBSD vehicles would launch from VAFB and fly over the Pacific Ocean towards a terminal impact location. For flight tests terminating at Kwajalein Atoll, only test RVs would impact within RMI territorial waters or on land at Illeginni Islet. All other activities relating to over-ocean flight would occur over international waters and are described and evaluated in a separate classified annex to the GBSD Test Program Environmental Assessment (USAF 2020a). Up to nine GBSD flight tests per year may use USAG-KA impact locations between FY 2024 and FY 2029. The proposed schedule for planned testing for both GBSD and MMIII is included in **Table 2-2**. There are currently up to six GBSD flight tests planned per year with a total of 28 GBSD flight tests between FY 2024 and FY 2029 (**Table 2-2**), but the USAF evaluates up to 9 tests per year in this BA to account for shifts in scheduling and planning.

Table 2-2. Proposed Number of GBSD and MMIII Flight Tests by Fiscal Year.

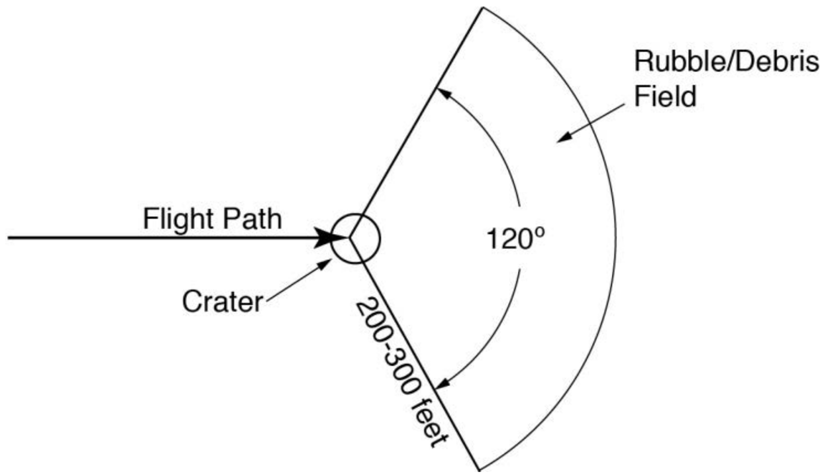
Test Program	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025	FY 2026	FY 2027	FY 2028	FY 2029
GBSD	0	0	0	4	4	5	6	5	4
MMIII	4	5	3	4	4	4	3	3	3
Total Flight Tests	4	5	3	8	8	9	9	8	7

Source: USAF 2020a
Abbreviations: FY = fiscal year, GBSD = Ground Based Strategic Deterrent, MMIII = Minuteman III

Testing in the RMI would be conducted in the same manner as for the previous and ongoing MMIII flight testing (USAF 2020b, USAF 2004, USAF 2015). The KMISS RV impact area would be in deep ocean waters east of Kwajalein Atoll, at least 5.6 km (3 nm) offshore of Gagan Islet (**Figure 2-1**). At Illeginni Islet, RVs would typically impact in ocean waters southwest of the islet. For MMIII testing, the test RVs were expected to typically impact up to approximately 792 m (2,600 ft) from the islet. The RV impact zone on Illeginni Islet (**Figure 2-1**) would only be used for up to three total tests through FY 2029, and only three total RV impacts would be expected. There is a small risk that a potential land impact test might result in an RV strike near the shallow waters or reef flats adjacent to the western end of Illeginni. For MMIII tests, the USAF estimated the probability of a shallow water or reef RV impact to be between 0.10 and 0.20 (USAF 2015).

When an RV strikes land at Illeginni Islet, a crater would likely form with soil, rubble, and RV fragments being ejected outward from the impact site. Prior MMIII RV tests on land have resulted in craters 6.1 to 9.1 m (20 to 30 ft) in diameter and 2.1 m to 3.0 m (7 to 10 ft) deep (USAF 2015). Any substances or components of which the RV is constructed (**Table 2-1**) would be ejected outward from the RV impact point. Based on observations from MMIII and other payload testing at Illeginni Islet, most of the RV materials and substrate ejecta would remain close to edge of the crater and the density of ejecta would be expected to decrease with distance from the impact point. For MMIII and other program flight tests, ejecta resulting from crater formations was estimated to extend no more than 60 to 91 m (200 to 300 ft) from the impact location (USAF 2015, U.S. Navy 2019) and would be primarily within an area 120 degrees downrange along the flight path (USAF 2015) (**Figure 2-5**).

A land impact test that strikes the shoreline could result in the dispersal of soil and rubble onto the shallow near shore reef flat. Although not planned as part of the GBSD Test Program, an RV shallow water impact (water depths of 3.0 m [10 ft] or less) on the reef at Illeginni Islet could create a crater 3.0 to 4.6 m (10 to 15 ft) wide and 0.6 to 1.2 m (2 to 4 ft) deep as estimated for MMIII testing. Prior tests have shown that no craters are formed in waters deeper than 3.0 m (10 ft) (USAF 2015).



Source: USAF 2015

Figure 2-5. Approximate Debris Field for Reentry Vehicle Land Impacts

During most GBSD tests, the RVs would remain intact until impact in ocean waters or on land. However, up to two test RVs per year may contain an explosive charge for purposes of conducting a high fidelity test. During such tests, the RV may detonate upon contact with the land or ocean waters or may detonate at some altitude (airburst). Because of the RV's hypersonic velocity at time of detonation, the resulting debris (much of which is aerosolized) impacts in a focused area (USAF 2015) at the impact site. For MMIII, the USAF estimated that the energy associated with high fidelity test debris is less than the energy associated with a conventional RV impact (USAF 2015).

2.2.4 Post-Flight Operations at Kwajalein Atoll

No post-test recovery and clean-up activities are anticipated for GBSD flight tests conducted at the KMISS site. For a nominal (i.e., according to plan) mission, RVs that impact in the deep ocean waters are not recovered.

At Illeginni Islet, post-test operations would include post-test recovery and clean-up activities involving human activity and vessel traffic. The LLNL sensor rafts would be recovered with a landing craft. Landing craft utilities or other vessels would be used to transport cleanup and recovery equipment, such as a backhoe or grader, from Kwajalein Islet to Illeginni Islet. Any visible RV debris on land, including hazardous materials, would be cleaned up by hand. Most RV debris would normally be found in the crater and backhoe may be used to excavate craters. Excavated material would be screened for RV debris and the crater would then be backfilled with soil and rubble that was ejected around the wall of the crater. All recovered RV and other man-made debris would be packaged and shipped back to Kwajalein Islet or the United States.

Lagoon and ocean reef flats are not intentionally targeted during GBSD testing; however, if RV debris entered these areas due to a shoreline land impact or an unintentional reef impact, recovery and cleanup of RV debris in these areas would be necessary. RV debris recovery would be attempted in areas within 152 to 305 m (500 to 1,000 ft) of the shoreline on the lagoon side of Illeginni Islet (USAF 2004). In shallow, nearshore areas recovery would be conducted similarly to land operations when tide conditions and water depth permit (USAF 2004, USAF 2015). If recovery operations were necessary in lagoon or ocean reef flats, USAF and USAG-KA personnel would coordinate with NMFS and USFWS to identify and use access corridors to the crater site to avoid unnecessary and accidental impacts to protected species and sensitive habitats. If RV debris were in deeper waters, a dive team from USAG-KA would be brought in to conduct underwater searches (USAF 2004). A ship would be used for recovery operations and a remotely operated vehicle would first be used to locate the debris field and then divers in scuba gear would recover debris manually (USAF 2004). In the event of an unplanned lagoon or reef flat impact, it is predicted that rubble ejected from an impact crater larger than one inch would be found within a 1.5–3 m (5–10 ft) radius around the crater rim (USAF 2015).

For nominal test activities, RV recovery operations would not be attempted in deeper waters on the ocean side of Illeginni Islet. Searches for RV debris would only be attempted out to depths of 15 to 30 m (50 to 100 ft) in an operation similar to lagoon recovery operations (USAF 2004).

2.3 Avoidance, Minimization, and Mitigation Measures

Over time and through consultation with NMFS and USFWS on MMIII activities, USAF has developed several avoidance, minimization, and mitigation measures to minimize the impacts of flight testing on protected species and their habitats. These measures, which would be implemented as part of GBSD test program activities at Kwajalein Atoll, are very similar to those implemented for MMIII (USAF 2015, USAF 2020b) and other recent test programs with payload impacts at Illeginni Islet (U.S. Navy 2019, U.S. Navy 2017). The following measures would be implemented as part of the Proposed Action and would be included in the DEP for GBSD Test Program activities at Kwajalein Atoll:

Marine Mammal and Sea Turtle Monitoring.

- During travel to and from impact zones, including Illeginni Islet, ship personnel would monitor for marine mammals and sea turtles to avoid potential ship strikes. Vessel operators would adjust speed or raft deployment based on expected animal locations, densities, and/or lighting and turbidity conditions.
- USAG-KA personnel would conduct a helicopter or fixed-wing aircraft overflight of the impact area three times over the week preceding a flight test and as close to launch as safely practical to survey for marine mammals and sea turtles. The final overflight would be within 1 day of the proposed launch. If personnel observe marine mammals or sea turtles in the vicinity, they would report such findings to the USAG-KA Environmental Office.
- Any observations of marine mammals or sea turtles during ship travel or overflights would be reported (including location, date, time, species or taxa, and number of individuals) to the USAG-KA Environmental Engineer who would maintain records of these observations and report sightings to NMFS and/or USFWS.

- Pre-flight monitoring by qualified personnel will be conducted on Illeginni Islet for sea turtles or sea turtle nests. For at least 8 weeks preceding the launch, Illeginni Islet would be surveyed by pre-test personnel for sea turtles, sea turtle nesting activity, and sea turtle nests. If possible, personnel will inspect the area within days of the launch. If sea turtles or sea turtle nests are observed near the impact area, observations would be reported to appropriate test and USAG-KA personnel for consideration in approval of the launch, and to USFWS and NMFS.
- Personnel will report any observations (including location, date, time, species, and number of individuals) of sea turtles or sea turtle nests on Illeginni Islet to the USAG-KA Environmental Engineer who would maintain records of these observations and report sightings to USFWS.
- Although unexpected, any dead or injured marine mammals or sea turtles sighted by post-flight personnel would be reported to the USAG-KA Environmental Office and USASMDC, who would then inform NMFS and USFWS. USAG-KA aircraft pilots otherwise flying in the vicinity of the impact and test support areas would also similarly report any opportunistic sightings of dead or injured marine mammals or sea turtles.

Hazardous Materials Measures.

- Vessel and equipment operations would not involve any intentional discharges of fuel, toxic wastes, or plastics and other solid wastes that could harm terrestrial or marine life.
- Any accidental spills from support equipment operations would be contained and cleaned up and all waste materials would be transported to Kwajalein Islet for proper disposal.
- Hazardous materials would be handled in adherence to the hazardous materials and waste management systems of USAG-KA. Hazardous waste incidents would comply with the emergency procedures set out in the Kwajalein Environmental Emergency Management Plan and the UES.
- Vessel and heavy equipment operators would inspect and clean equipment for fuel or fluid leaks prior to use or transport and would not intentionally discharge fuels or waste materials into terrestrial or marine environments.
- All equipment and packages shipped to Kwajalein Atoll will undergo inspection prior to shipment to prevent the introduction of alien species into Kwajalein Atoll.
- Following a land-impact test, the USAF and USAG-KA would collect soil and groundwater samples at various locations around the impact site and test the samples for beryllium (Be), DU, and other metals. Testing results that exceed UES criteria would require a soil investigation as detailed in the UES and may require subsequent soil removal or other remediation.

Reef Protection Measures.

- To avoid impacts on coral heads in waters near Illeginni Islet, sensor rafts would not be located in waters less than 3 m (10 ft) deep.

- 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 (i.e., reef habitat). Any impacts to biological resources would be reported to the Appropriate Agencies, with USFWS and NMFS offered the opportunity to inspect the impact area to provide guidance on mitigations.
- If an inadvertent impact occurs on the reef, reef flat, or in shallow waters less than 3 m (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.
- If any man-made debris were to enter the marine environment and divers were required to search for payload debris on the adjacent reef flat, they would be briefed prior to operations about coral fragility and provided guidance on how to carefully retrieve the very small pieces of payload debris that they would be looking for.

General Measures at Illeginni Islet.

- At Illeginni Islet, should any missile components or debris impact areas of sensitive biological resources (i.e., sea turtle nesting habitat or coral reef), a USFWS or NMFS biologist would be allowed to provide guidance and/or assistance in recovery operations to minimize impacts on such resources. To the greatest extent practicable, protected marine species including invertebrates will be avoided or effects to them will be minimized. This may include movement of these organisms out of the area likely to be affected.
- Debris recovery and site cleanup would be performed for the land impact. To minimize long-term risks to marine life, all visible project-related man-made debris would be recovered during post-flight operations. In all cases, recovery and cleanup would be conducted in a manner to minimize further impacts on biological resources.
- For recovery and rehabilitation of any injured migratory birds or sea turtles found at Illeginni Islet, USFWS and NMFS would be notified to advise on best care practices and qualified biologists would be allowed to assist in recovering and rehabilitating any injured sea turtles found.
- During post-test recovery and cleanup, should personnel observe endangered, threatened, or other species requiring consultation moving into the area, work would be delayed until such species were out of harm’s way or leave the area.

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3.0 LISTED SPECIES AND CRITICAL HABITAT IN THE ACTION AREA

This section includes the species listed as consultation species under Section 3-4 of the UES that occur or have the potential to occur in the Kwajalein Atoll portion of the Action Area and may be affected by the Proposed Action (**Table 3-1**). To determine whether the Proposed Action may affect these species or the habitats on which they depend, each species or habitat was evaluated based on the potential for exposure and response to Proposed Action stressors. No critical habitat has been designated in the RMI; therefore, no designated critical habitat occurs in the Action Area.

Because the Action Area at Kwajalein Atoll is the same for many DoD test programs, a regularly updated document detailing the baseline conditions at sites used for DoD testing at Kwajalein Atoll is maintained by USASMDC contractors (**Appendix A**). This document includes species descriptions for UES-listed species in the Action Area as well as descriptions of the most recent survey data available for these species at USAG-KA. Rather than include detailed species descriptions and baseline conditions in this section, the baseline conditions document is provided in **Appendix A**. For each species in **Table 3-1**, **Appendix A** provides the species listing status, a general description, the known distribution, threats to the species, and population of each species in the Action Area.

For more than 20 years, Kwajalein Atoll has been the terminal location for ICBM and other flight tests. Vehicle impacts from these tests have occurred and continue to occur on and in the vicinity of Illeginni Islet and in ocean waters at KMISS. All U.S. Government activities that occur on USAG-KA and RTS controlled islands, the Kwajalein Mid Atoll Corridor, or elsewhere in the RMI have been subject to regulations in the UES since December 1995 (USASMDC/ARSTRAT 2018). The proposed GBSD flight test activities are consistent with the ongoing RTS mission and are well within the limits of current operations of RTS and USAG-KA.

Table 3-1. Species in the Action Area Requiring Consultation under the UES that May be Affected by the Proposed Action.

Scientific Name	Common Name	UES Consultation Species Listing Status[(1)]			
		ESA	MMPA	RMI Statute	UES 3-4.5.1(a)
Marine Mammals					
Balaenoptera musculus	Blue whale	E	Migratory	1	
B. physalus	Fin whale	E	Migratory		
Delphinus delphis	Short-beaked common dolphin			2	
Feresa attenuata	Pygmy killer whale		Resident		
Globicephala macrorhynchus	Short-finned pilot whale		Migratory		
Grampus griseus	Risso's dolphin		Resident		
Kogia breviceps	Pygmy sperm whale		Migratory		
Megaptera novaeangliae	Humpback whale (Western North Pacific DPS)	E[(2)]	Migratory		
Mesoplodon densirostris	Blainville's beaked whale		Migratory		
Orcinus orca	Killer whale		Resident		
Peponocephala electra	Melon-headed whale		Resident		
Physeter macrocephalus	Sperm whale	E	Resident	1	
Stenella attenuata	Pantropical spotted dolphin			2	
S. coeruleoalba	Striped dolphin			2	
S. longirostris	Spinner dolphin		Resident	2	
Tursiops truncatus	Bottlenose dolphin		Resident		
Reptiles					
Chelonia mydas	Green turtle (Central West Pacific DPS)	E		1,3	
Eretmochelys imbricata	Hawksbill turtle	E		3	
Fish					
Alopias superciliosus	Bigeye thresher shark				x
Carcharhinus longimanus	Oceanic whitetip shark	T			
Cheilinus undulatus	Humphead wrasse				x
Manta alfredi	Reef manta ray				x
M. birostris	Oceanic giant manta ray	T			
Sphyrna lewini	Scalloped hammerhead (Indo-West Pacific DPS)	T			
Thunnus orientalis	Pacific bluefin tuna				x
Corals					
Acropora microclados					x
A. polystoma					x
Cyphastrea agassizi	Agassiz's coral				x
Heliopora coerulea	Blue coral				x
Pavona venosa					x
Pocillopora meandrina		C			
Turbinaria reniformis					x

Scientific Name	Common Name	UES Consultation Species Listing Status(1)			
		ESA	MMPA	RMI Statute	UES 3-4.5.1(a)
Mollusks					
Hippopus hippopus	Giant clam	C			
Tectus niloticus(3)	Top shell snail			3	
Tridacna squamosa	Giant clam	C			

Sources: USASMDC/ARSTRAT 2018, NOAA 2020, U.S. Navy 2019

Notes:

(1) UES Consultation Species Listing Status based on Appendix 3-4A of the UES (USASMDC/ARSTRAT 2018).
RMI Statutes: 1 = Endangered Species Act 1975, Title 8 MIRC Chapter 3; 2 = Marine Mammal Protection Act 1990, Title 33 MIRC Chapter 2; 3 = Fisheries Act 1997, Title 51 MIRC Chapter 2;
UES Section 3-4.5.1(a): X = Contained in RMI Environmental Protection Agency letter, 12 March 2015, or RMI Environmental Protection Agency letter, 28 September 2016

(2) The DPSs of humpback whales likely in the Action Area (Oceania DPS) are not listed under the ESA; however, there is some uncertainty about which DPS whales in the Action Area belong to (see Appendix A).

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

Abbreviations: C = Species is a candidate for listing under the ESA, DPS = Distinct Population Segment, E = ESA Endangered, ESA = U.S. Endangered Species Act, MMPA = Marine Mammal Protection Act, T = ESA Threatened, UES = United States Army Kwajalein Atoll Environmental Standards (USASMDC/ARSTRAT 2018 Section 3-4.5.1).

3.1 Marine Mammals

Sixteen cetacean species protected under the UES have the potential to occur in deeper waters of the Action Area (**Table 3-1**) including KMISS and the vicinity of Illeginni Islet. Four of these species are listed under the ESA. All marine mammals discussed in this section are also protected under the MMPA (16 USC § 1361 et seq.). Most of the cetacean species listed in **Table 3-1** have been observed in the RMI (Miller 2007, Reeves et al. 1999). For other species such as pygmy killer whale (*Feresa attenuata*), Risso's dolphin (*Grampus griseus*), pygmy sperm whale (*Kogia breviceps*), and Blainville's beaked whale (*Mesoplodon densirostris*), potential presence in the Action Area is based on information regarding life history, including feeding patterns, known distribution, and migration patterns, as well as range distribution form the literature sources (NOAA 2020, Reeves et al. 2002, Perrin et al. 2002). The dugong (*Dugong dugong*) may have occurred historically at Kwajalein Atoll according to an appendix of the UES. However, because this species has not been reported in the vicinity of the Action Area for many decades, it would not be affected by the Proposed Action and is not included in this BA. There is no designated critical habitat in the Action Area for marine mammals.

Species descriptions of marine mammals in the Action Area (**Table 3-1**) as well as a summary of threats to cetaceans, including the potential impacts of noise exposure, are included in **Appendix A**.

3.2 Reptiles

The only sea turtle species with the potential to be present in the Kwajalein Atoll portion of the Action area are green (*Chelonia mydas*) and hawksbill (*Eretmochelys imbricata*) turtles (**Table 3-1**). Both of these species are listed under the ESA and are UES consultation species. Species descriptions for these turtles are included in **Appendix A** along with a summary of threats to sea turtles and a summary of sea turtle hearing. These species have the potential to occur in waters of Kwajalein Atoll but also have the potential to haul out or nest on land at Illeginni Islet. While suitable sea turtle nesting and haulout habitat occurs on Illeginni Islet (**Figure 3-1**), no sea turtle nests or nesting activity have been observed on Illeginni Islet in over 20 years (since 1996).

3.3 Fish

The marine environment of the Action Area provides a diversity of fish habitat including many reef habitats typical of atolls in the central Pacific, protected lagoon habitats, and deeper ocean habitats surrounding Kwajalein Atoll. Seven species of fish that require consultation under the UES have the potential to occur in the Action Area (**Table 3-1**). The bigeye thresher shark (*Alopias superciliosus*), oceanic whitetip shark (*Carcharhinus longimanus*), oceanic giant manta ray (*Manta birostris*), and Pacific bluefin tuna (*Thunnus orientalis*) are primarily open ocean species and have the potential to occur in deep ocean waters of Kwajalein Atoll, including KMISS and in the vicinity of Illeginni Islet. Relatively little is known about scalloped hammerhead sharks (*Sphyrna lewini*), but this species does have an affinity for coastal environments where it is known to give birth to live young. Juvenile scalloped hammerheads are known to occur in relatively shallow nearshore waters, and adults are known to occur in deeper coastal waters. This species may be found in both nearshore and deeper ocean waters of Kwajalein Atoll. The reef manta ray (*Manta alfredi*) is a shallow water species found primarily in or near reef habitats and may be present near Illeginni Islet. The humphead wrasse (*Cheilinus undulatus*) is reef-associated and found in reef habitat throughout Kwajalein Atoll including the waters surrounding Illeginni Islet.

Species descriptions for the UES-listed fish in the Action Area (**Table 3-1**) are included in **Appendix A** along with a summary of threats to fish and a summary of fish hearing abilities.

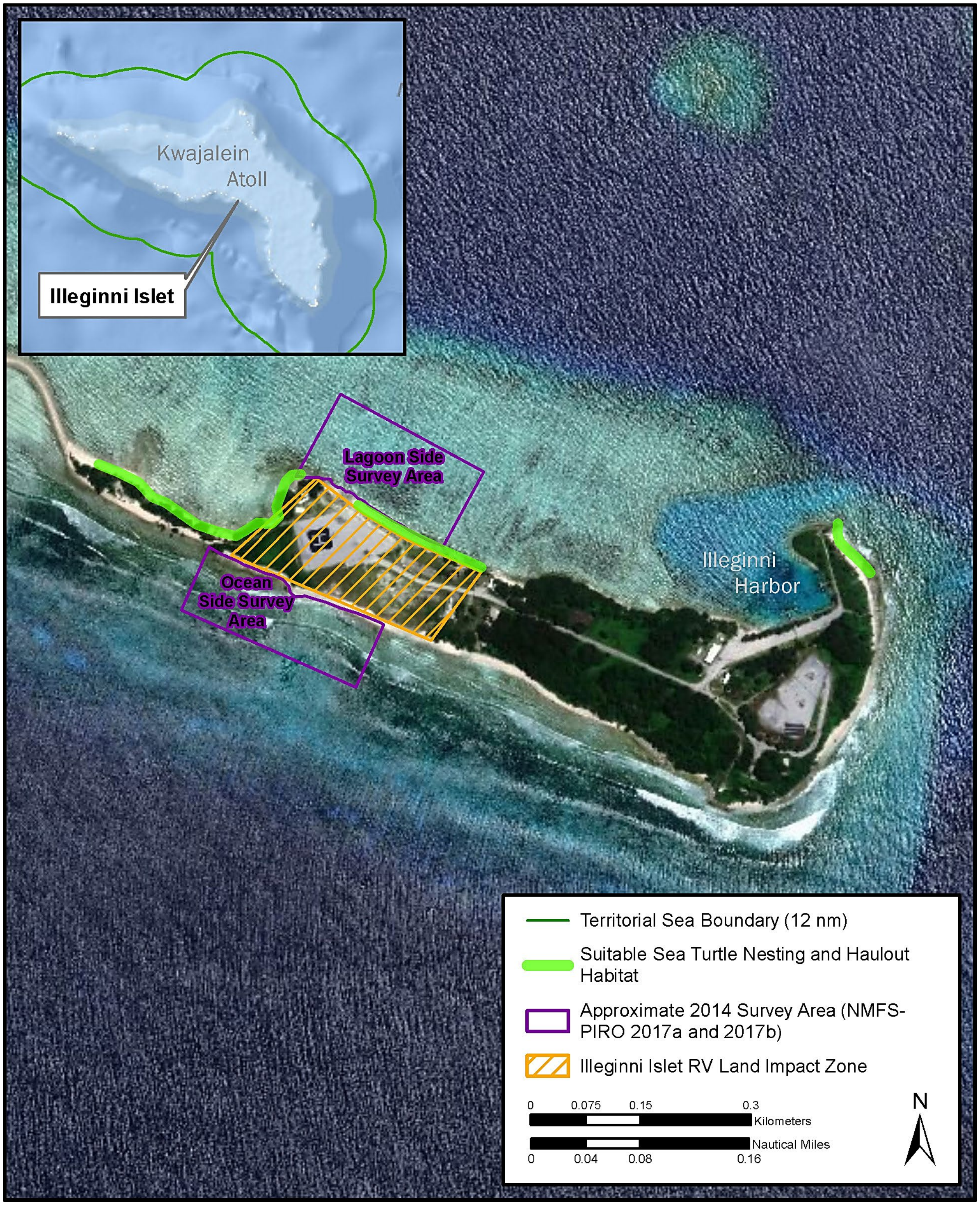

Figure 3-1. Habitats and Survey Areas at Illeginni Islet, Kwajalein Atoll.

3.4 Corals

The marine environment surrounding Illeginni Islet supports a community of corals that is typical of reef ecosystems in the tropical insular Pacific. In 2014, NMFS surveyed the reef habitats offshore of the RV impact area at Illeginni Islet (**Figure 3-1**) (NMFS-PIRO 2017a). Based on these NMFS surveys (NMFS-PIRO 2017a), seven UES-consultation coral species (*Acropora microclados*, *A. polystoma*, *Cyphastrea agassizi*, *Heliopora coerulea*, *Pavona venosa*, *Pocillopora meandrina*, and *Turbinaria reniformis*) occur in reef habitats offshore of the RV impact area on Illeginni Islet and have the potential to be subject to the effects of the Proposed Action as adults (**Table 3-1**). Descriptions of these seven UES-consultation coral species can be found in **Appendix A** along with a summary of coral characteristics, threats to corals, and coral reproduction in the Action Area. An additional 15 UES-consultation species have the potential to occur in the Action Area as larvae (see **Table 3-2**).

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

All shallow-water corals of the Marshall Islands are found throughout much of the insular Pacific and the coral triangle (i.e., the area surrounding Indonesia and the Philippines) (Sakashita and Wolf 2009). No known shallow-water coral species are endemic to the Marshall Islands. Within Kwajalein Atoll, all coral species found at Illeginni Islet in NMFS/USFWS biennial inventories are found on at least one other Kwajalein Atoll islet (n = 11 islets) (Table 6 in **Appendix A**) and at other locations in the Marshall Islands (Beger et al. 2008, Pinca et al. 2002, USFWS and NMFS 2012).

No adults of UES-consultation coral species are known to occur in the KMISS or vicinity of Illeginni Islet portions of the Action Area. Deep-water corals may occur in these areas; however, based on the water depth, corals in these areas would likely be UES-coordination species and not consultation species.

3.4.1 Coral Species Not Affected

The Proposed Action has the potential to impact coral species by direct contact from impact debris or ejecta from crater formation on land, by shock waves from impact, or through human activity and equipment operation. These activities would only have the potential to affect adult coral colonies in habitats near the RV impact area on and in the vicinity of Illeginni Islet.

Only seven UES-consultation coral species have been recorded as adults in the area of potential effect offshore of Illeginni Islet (**Table 3-1**). The other 15 UES-consultation species with the potential to occur in the Action Area (**Table 3-2**) are only likely to occur in the Action Area as gametes or larvae. Four of these species, *Acropora tenella*, *A. vaughani*, *Leptoseris incrustans*, and *Pavona cactus*, occur on lower reef slopes which occur well below areas that may be affected by the proposed activities, and for this reason, adults would not be adversely 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 where debris deposition or shockwaves might occur. The other species listed in **Table 3-2** have either not been recorded near Illeginni Islet or have been recorded at other locations near Illeginni Islet but have not been recorded in the area potentially affected by impact debris or shock waves (NMFS PIRO 2017a). Adults of the species listed in **Table 3-2** are not expected to be exposed to stressors related to the payload impact and would not be affected by the Proposed Action.

Table 3-2. Consultation Coral and Mollusk Species Not Affected by the Proposed Action.

Scientific Name	Common Name
Corals	
Acanthastrea brevis	
Acropora aculeus	
A. aspera	
A. dendrum	
A. listeri	
Acropora speciosa	
A. tenella	
A. vaughani	
Alveopora verrilliana	
Leptoseris incrustans	
Montipora caliculata	
Pavona cactus	
P. decussata	
Turbinaria mesenterina	
T. stellulata	
Mollusks	
Pinctada margaritifera	Black-lipped pearl oyster
Tridacna gigas	Giant clam

At various times of the year the gametes (eggs and sperm) and larvae of reef-associated invertebrates may occur in ocean waters. For corals, this is generally July to December and particularly the week following the August and September full moons. The densities of coral larvae in the Action Area, especially for UES-consultation species, are likely to be very low except during peak spawning when density may be high over the reef for a short period of time.

Only one to three flight tests would involve impact on Illeginni Islet which might introduce debris into nearshore reef habitats, and the reef area with the potential to be impacted is a small portion of the reef area at Illeginni Islet and throughout Kwajalein Atoll. Therefore, the Proposed Action would have no effect on gamete or larvae concentrations of UES-consultation coral species.

3.5 Mollusks

Five mollusk species that require consultation under the UES have the potential to occur in the Action Area. In 2014, NMFS surveyed the reef habitats offshore of the RV impact area at Illeginni Islet (**Figure 3-1**) (NMFS-PIRO 2017b). Based on these NMFS surveys (NMFS-PIRO 2017b), three UES-consultation mollusk species (*Hippopus hippopus*, *Tectus niloticus*, and *Tridacna squamosa*) (**Table 3-1**) are likely to occur in the area offshore of Illeginni Islet where adults would have the potential to be subject to the effects of the Proposed Action. Two additional UES-consultation species, *Pinctada margaritifera* and *Tradacna gigas* (**Table 3-2**), are unlikely to occur in the area of potential effect offshore of Illeginni Islet as adults. Descriptions of these UES-consultation mollusk species and their distribution in the Action Area can be found in **Appendix A**.

All of the UES-consultation species with the potential to occur in the Action Area are fairly widespread in Kwajalein Atoll. During surveys of Kwajalein Atoll since 2010, all of the species listed in **Table 3-1** and **Table 3-2** have been observed in waters offshore of at least 8 of 11 surveyed islets and all but *Pinctada margaritifera* have been observed at multiple sites in the mid-atoll corridor (see Table 8 in **Appendix A**).

No UES-consultation mollusk species are known to occur in the KMISS or vicinity of Illeginni Islet deep water RV impact areas as adults.

3.5.1 Mollusk Species Not Affected

The Proposed Action has the potential to impact mollusk species by direct contact from impact debris or ejecta from crater formation on land, by shock waves from impact, or through human activity and equipment operation. These activities would only have the potential to affect adult mollusks in habitats offshore of the RV impact area on Illeginni Islet.

Pinctada margaritifera and *Tradacna gigas* have not been recorded in the area of potential effect offshore of Illeginni Islet and are not likely to occur in the area as adults. Adults of these species are not expected to be exposed to stressors related to the RV impact and would not be affected by the Proposed Action.

The black-lipped pearl oyster (*Pinctada margaritifera*) has been observed on the lagoon-side reef slope during biennial resource surveys at Illeginni Islet (see Table 8 in **Appendix A**). Since *Pinctada margaritifera* is a reef slope dwelling species, it occurs below the areas that have the potential to be affected by Proposed Action RV impacts at Illeginni islet. Therefore, this species would not be affected by direct contact or any other Proposed Action stressors.

The giant clam *Tridacna gigas* has been observed at biennial survey locations at Illeginni Islet and throughout Kwajalein Atoll (see Table 8 in **Appendix A**). This species was observed at all surveyed Kwajalein Atoll islets since 2010 but had a relatively low distribution at these islets; being found at only 22% of surveyed sites (28 of 125). While *Tridacna gigas* was found at 40% of sites (2 of 5) at Illeginni Islet, including at a lagoon reef crest site and in Illeginni Harbor, this species has not been observed in habitats near the proposed RV impact locations (NMFS-PIRO 2017a and 2017b). Since adults of this species are not known to occur in the area potentially affected by direct contact, *Tridacna gigas* would not be affected by the Proposed Action.

Larvae of all the mollusk species listed in **Table 3-1** and **Table 3-2** have the potential to occur in the Action Area; however, the Proposed Action would not affect larval concentrations at Kwajalein Atoll and would have no effect on these species. Giant clams (*Hippopus* and *Tridacna* species) are synchronous spawners where release of sperm is triggered by the presence of a spawner with ripe eggs (Munro 1993). Due to the limited time frame of gamete viability (viable up to 8 hours in *T. squamosa* but fertilization success decreased within hours of spawning [Neo et al. 2015]), viable gametes are not likely to be found far from adult clams. Giant clam larvae are considered the dispersal phase where ambient currents and larval swimming speed influence long-distance dispersal (Neo et al. 2015). This long-distance dispersal is limited by the time period during which larvae are able to survive before settlement/recruitment. For most giant clam species, the period from spawning to settlement is approximately 14 days (Ellis 1997, Neo et al. 2015). Black-lipped pearl oysters are also broadcast spawners, producing 40-50 million eggs per female (Thomas et al. 2014). First stage larvae form within 24 hours of fertilization and the pelagic larval stage lasts for 15 to 30 days before larvae metamorphose and settle to the bottom (Thomas et al. 2014). Top shell snails (*Tectus niloticus*) females release more than 1 million eggs (SPC 2016) and pelagic larvae are free-swimming for at least 3 to 5 days before metamorphosis and subsequent settlement on substrate (SPC 2016). Due to the short time between fertilization and settlement in these mollusk species and their time-limited dispersal capability, the abundance of mollusk larvae (especially viable larvae) is likely extremely low in the Action Area. Since proposed flight tests are discrete events, most tests would have RV impact in deep ocean waters, and proposed activities in the marine environment are limited, the Proposed Action would have no effect on gamete or larvae concentrations of UES-consultation mollusk species.

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4.0 EFFECTS OF THE PROPOSED ACTION

This section describes how the Proposed Action has the potential to directly or indirectly affect listed species, their habitats, and/or designated critical habitats. Direct effects are the immediate effects of the Proposed Action on species, their habitats, or designated critical habitat. Indirect effects are effects of the Proposed Action which occur at a later point in time. The following describes the elements of the Proposed Action that may act as stressors on UES-consultation species and analysis of the effects of those stressors on those species. No critical habitat has been designated in the RMI; therefore, no designated critical habitat occurs in the Action Area and there would be no effects to critical habitat. As described in **Section 2.2**, many of the stressors for the Proposed Action are of the same type and magnitude as the MMIII action and other test programs; therefore, portions of the MMIII Modification BA (USAF 2015), the NMFS BO on that action (NMFS 2015a), and Flight Experiment 2 (FE-2) BA (U.S. Navy 2019) are excerpted and used in this document as cited in the text.

The Proposed Action has the potential to directly or indirectly affect UES listed species and their habitats due to the following stressors: elevated sound pressure levels; direct contact and shock waves; exposure to hazardous materials; disturbance due to human activity or equipment operation; and vessel strike. As stated previously, proposed GBSD activities at Kwajalein Atoll are very similar to those of the MMIII action as evaluated and consulted on in 2015 (USAF 2015, NMFS 2015a). The potential stressors for UES-consultation species in the Action Area are described in this section and summarized in **Table 4-1**. The effects of the Proposed Action stressors are evaluated for each species or for a group of species (i.e., cetaceans) where the effects are expected to be essentially identical for all species within a group.

4.1 Exposure to Elevated Noise Levels

4.1.1 Elevated Noise Level Stressors

The Proposed Action has the potential to result in elevated sound pressure levels both in the air and underwater. The primary elements of the Proposed Action that would result in elevated noise levels are: (1) sonic booms, (2) impact of the payload, (3) vessel operation, and (4) human activity and equipment operation.

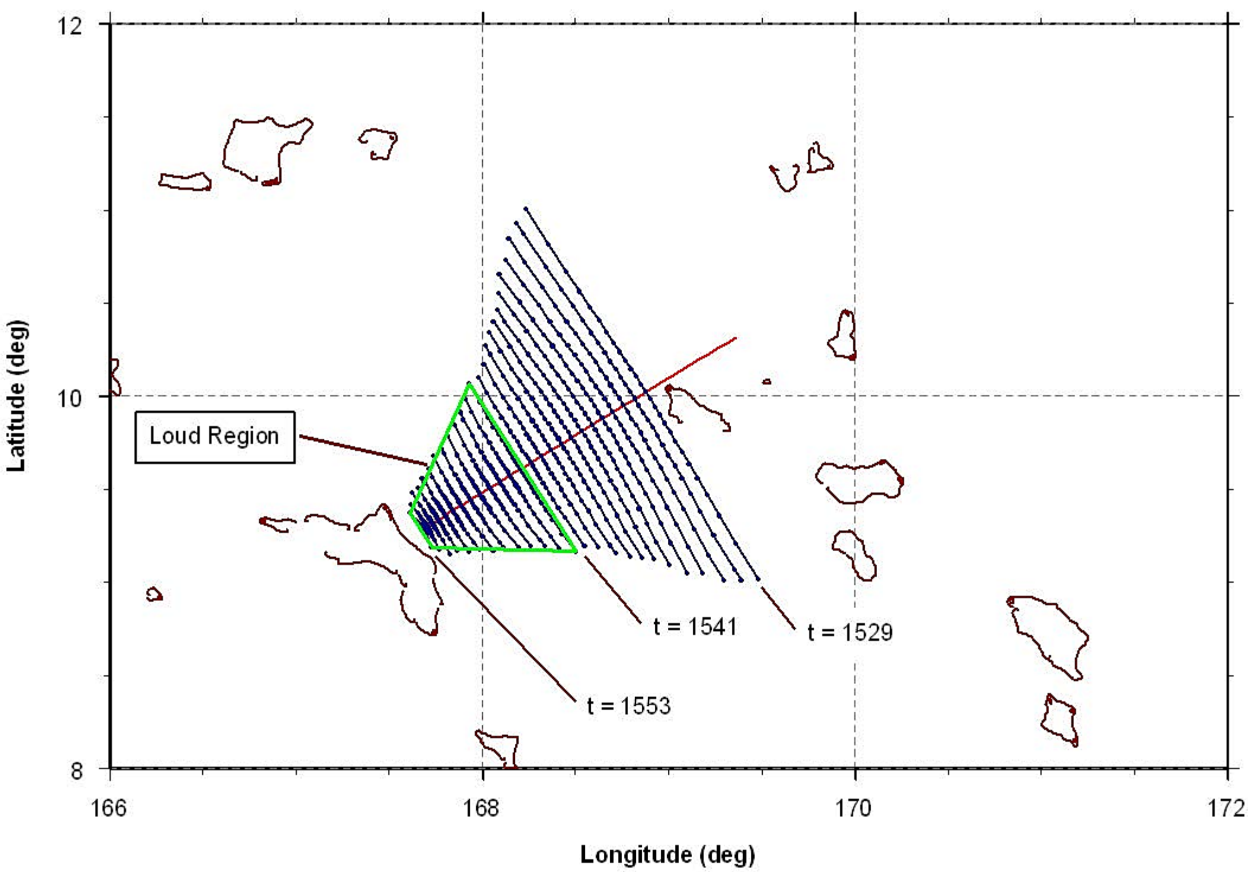
Table 4-1. Stressors Associated with GBSD Test Activities at Kwajalein Atoll.

Stressor	Deep Ocean Waters of KMISS and in the Vicinity of Illeginni Islet	Illeginni Islet and Nearshore Habitats
Number of Tests		
	Six planned tests per year between FY 2024–2029 with up to nine possible per year. One to three RVs per test.	Up to three total tests with land impacts FY 2024–2029. Shoreline or shallow water impact not planned or expected.
Elevated Sound Pressure Levels		
Sonic Booms	Maximum sound pressure up to 176 dB in-water (re 1 μPa) at the surface and 150 dB in-air (re 20 μPa) near the point of impact. Duration 0.04 second for loudest sounds and 0.27 second for weakest sonic boom.	Same as for deep ocean waters.
Payload Impact	Estimated maximum of up to 240 dB re 1 μPa at 3.1 m (10 ft) from impact. Duration on the order of seconds.	No estimates for terrestrial impact noise. Due to refraction at the air-water interface and attenuation, loud sounds from terrestrial impact not expected in the water.
Vessel Activity	Range from 150 to 190 dB re 1 μPa. Similar to ongoing vessel activity at USAG-KA.	Same as for deep ocean waters.
Direct Contact and Shock Waves		
Cratering	No cratering in waters great than 3 m (10 ft) deep.	RV land impact craters 6–9 m (20–30 ft) in diameter and 2–3 m (7–10 ft) deep.
Ejecta/Debris	No ejecta dispersion in waters over 3 m (10 ft) deep. For most tests, the RV would enter the water in one piece and then fragment.	Ejecta estimated to extend 60 to 91 m (200 to 300 ft) from the impact location. Shoreline impact not planned or expected.
Shock Waves	No ground borne propagation of shock waves strong enough to damage corals in waters deeper than 3 m (10 ft). Effects due to pressure waves in-water are encompassed in “elevated sound pressure level” estimates.	Propagation of ground-borne shock waves strong enough to damage corals up to 37.5 m (123 ft) from the point of impact.

Stressor	Deep ocean waters of KMISS and in the Vicinity of Illeginni Islet	Illeginni Islet and nearshore habitats
Exposure to Hazardous Materials		
	Potential introduction of RV materials into marine environments. RV components expected to sink to the ocean floor relatively quickly. Materials such as Be and DU in RV fragments are highly insoluble.	Potential introduction of RV materials into terrestrial and marine environments. All visible test debris would be cleaned up where possible. Potential for accidental spills or leaks from support equipment. Avoidance measures would be implemented.
Human Activity and Equipment Operation		
Human Activity	KMISS: no pre-test or post-test activities. Vicinity of Illeginni Islet: No post-test recovery operations in waters greater than 30 m (100 ft) deep. If debris recovery were required, would involve scuba divers for manual cleanup.	On Illeginni Islet: Increased human activity for several months. Equipment placement, cleanup operations, heavy equipment use. Nearshore Waters: Sensor deployment and recovery in waters greater than 3 m (10 ft) deep. Potential manual debris recovery.
Equipment Operation	KMISS: no equipment operation. Vicinity of Illeginni Islet: Sensor raft operation in waters at least 3 m (10 ft) deep. If debris recovery were required, would involve remotely operated vehicle.	On Illeginni Islet: Several helicopter trips for personnel and equipment transport. Heavy equipment such as a backhoe or loader for equipment placement and post-test cleanup. Nearshore Waters: Sensor raft operation.
Vessel Strike	KMISS: no vessel operation. Vicinity of Illeginni Islet: Several vessel round trips for placement of self-stationing sensor rafts.	Several vessel round trips for personnel and equipment transport pre- and post-test. Vessel(s) used to place several self-stationing rafts.

Abbreviations: μPa = micropascals, Be = beryllium, dB = decibels, DU = depleted uranium, ft = feet, FY = fiscal year, KMISS = Kwajalein Missile Impact Scoring System, m = meter(s), RV = reentry vehicle, USAG-KA = United States Army Garrison = Kwajalein Atoll.

Sonic Booms. The vehicle would fly at speeds sufficient to generate sonic booms from close to launch and extending to impact in Kwajalein Atoll. Sonic booms create elevated pressure levels both in the air and underwater. Models were used to estimate sound pressure levels for sonic booms for the MMIII flight tests (Moody 2004, USAF 2015), and those estimates are used for the Proposed Action. As each descending test RV approaches KMISS at hypersonic velocity, sonic booms are generated over a very broad area of the open ocean northeast of the atoll and continue southwesterly toward the point of impact (**Figure 4-1**) (USAF 2015). Here the sonic boom footprint narrows to just a few miles on either side of the flight path (USAF 2015). At the ocean surface, the sound pressure levels for the sonic booms would vary from 91 decibels (dB) in-air (referenced to [re] 20 micropascals [μPa]) (117 re 1 μPa in-water) at the eastern-most range and increase to 150 dB in-air (176 re 1 μPa in-water) at the western-most range, close to the point of impact (USAF 2015). For those RVs that impact in the KMISS area, the sonic boom footprint would occur almost entirely over the open ocean (USAF 2015). The duration for sonic boom overpressures produced by the RVs ranges from 40 milliseconds where the boom is strongest to 124 milliseconds where it is weakest (Moody 2004, USAF 2015).



Source: USAF 2015

Figure 4-1. Representative Sonic Boom Footprint for an RV Impact at Kwajalein Atoll.

RV Impact Noise. Impact of the RV at the terminal end of the flight would result in elevated sound levels in-air and underwater. Sound pressure estimates for the MMIII RV impact in ocean waters were up to 240 dB re 1 μPa at 3.1 m (10 ft) (USAF 2015). The sound pressures would decrease with water depth and distance from the point of RV impact. Using a point source attenuation model with spherical spreading coefficient, sound pressures attenuate to 230 dB re 1 μPa at 10 m (33 ft) from RV splashdown, 224 dB re 1 μPa at 20 m (65 ft), and 202 dB re 1 μPa at 251 m (824 ft).

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

Vessel Noise. Vessels would be used to move equipment and personnel to Illeginni Islet and to deploy sensor rafts. NMFS estimates that large vessels can create sounds ranging from 170–190 dB (re 1 μPa) and sounds from smaller vessels would range from 150–170 dB (re 1 μPa) (NMFS 2019).

Human Activity and Equipment Operation. Acoustic effects associated with post-test human activity and equipment operations would be consistent with any other land or sea activity that uses mechanized equipment and would primarily be in terrestrial habitats centered on the payload impact location.

4.1.2 Effects of Elevated Noise Levels

Elevated noise levels have the potential to affect the behavior and hearing sensitivity in marine mammals, sea turtles, and fish. 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 these effects depends on the frequency, intensity, and duration of the sound pressures as well as on the hearing ability and physiology of the organism. The species considered in this document have varying hearing abilities and thresholds for effects, which have been detailed in several documents including the FE-2 BA (U.S. Navy 2019), NMFS BO for FE-2 (NMFS 2019), and NMFS Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (NOAA 2018). The detailed descriptions of general sound characteristics, justification for thresholds for effect in consultation organisms, and analysis methodology used in these documents is incorporated by reference and noise effect thresholds are summarized in **Table 4-2**.

Table 4-2. Thresholds for PTS, TTS, and Behavioral Disruption in Functional Hearing Groups from Single (Non-continuous) Exposure to Impulsive In-water Sounds.

Functional Hearing Group	PTS threshold (SPLpeak)	TTS Threshold (SPLpeak)	Behavioral Disruption
Low-frequency Cetaceans (*Balaenoptera* and *Megaptera* whales)	219 dB	213 dB	160 dB
Mid-frequency Cetaceans (*Delphinus*, *Grampus*, *Stenella*, and *Tursiops* dolphins; *Feresa*, *Globicephala*, *Mesoplodon*, *Orcinus*, *Peponocephala*, and *Physeter* whales)	230 dB	224 dB	160 dB
High-frequency Cetaceans (*Kogia* whales)	202 dB	196 dB	160 dB
Sea Turtles	230 dB(1)	224 dB	160 dB SELcum
Fish	229 dB(2)	186 dB SELcum(2)	150 dB

Sources: U.S. Navy 2019, NMFS 2019, NOAA 2018, Finneran and Jenkins 2012, Popper et al. 2014

Notes: All sound pressures in this table are in dB SPL_{peak} re 1 μPa unless indicated.

(1) The PTS threshold listed for sea turtles is based on the non-lethal injury threshold in Finneran and Jenkins 2012.

(2) The PTS threshold for fish with swim bladders is based on the mortality/mortal injury threshold in NMFS 2015a and Popper et al. 2014. Thresholds in fish are not specific to auditory injury.

Abbreviations: dB = decibels, PTS = Permanent Threshold Shift, SEL = Sound Exposure Level, SPL = Sound Pressure Level, TTS = Temporary Threshold Shift

In general, a noise level 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 noise levels may induce other physical injury or, in extreme cases, even death. The extent of physical injury would depend on the intensity and duration of the sound as well as the anatomy of each species. (U.S. Navy 2019)

A temporary threshold shift (TTS) is when an organism is exposed to sound pressures below the threshold of permanent physical injury but may result in temporary hearing alteration. These sound levels may impede a marine mammal's, bird's, sea turtle's, or fish's ability to hear, even after the exposure has ended, temporarily raising the threshold at which the animal can hear. TTS can temporarily impair an animal's ability to communicate, navigate, forage, and detect predators. The onset of threshold shift in hearing in cetaceans depends on the total exposure to sound energy, a function of sound pressure level, and duration of exposure. As a sound gets louder, the duration required to induce threshold shifts gets shorter (National Research Council 2003). (U.S. Navy 2019)

Another common effect of elevated noise levels is behavioral modification. Most observations of behavioral responses to anthropogenic sounds have been limited to short-term behavioral responses, which include disturbance to feeding, resting, or social interactions. Responses such as sudden diving, change in swim speed, and change in respiration rate can have an effect on foraging and can decrease the foraging efficiency of various species. A disruption in foraging, or a reaction that forces an animal to expend energy diving or fleeing, may also affect the animal's energy budget (energy income against expenditure), with the outcome of less energy available for important biological functions. Responses can also include changes in the type or timing of an animal's vocalizations and masking of sounds produced from the impacted individual or from other individuals of the same species in the area such that those near the sound source would not hear those calls. Marine mammals have been observed to decrease their vocalizations in response to noise (Aguilar de Soto 2006, International Whaling Commission 2007), which can have further implications on breeding, feeding, and social interacting. (U.S. Navy 2019)

Corals and mollusks can perceive sounds (Fritzsch et al. 2007, Mooney et al. 2010, Vermeij et al. 2010), but much less than other invertebrates more specialized to produce and sense sounds (e.g., crabs and shrimp) (Patek and Caldwell 2005, Waikiki Aquarium and University of Hawai`i-Manoa 2009). Marine invertebrates are likely only sensitive to water particle motion caused by nearby low-frequency sources, and likely do not sense distant or mid- and high-frequency sounds (U.S. Navy 2015). While there is some evidence that long-term or very intense sounds may induce stress effects on invertebrates (U.S. Navy 2015), research on the effects of sound on invertebrate species is limited. Long-duration sounds have the potential to mask biologically relevant sounds for marine invertebrates (U.S. Navy 2015). There is some evidence that crustacean and coral larvae use reef sound for orientation during settlement (Vermeij et al. 2010) and elevated sound levels have the potential to mask the natural acoustic cues (U.S. Navy 2015). (U.S. Navy 2019)

Effects of Sonic Booms. At its loudest (176 dB in-water), the sonic boom at Kwajalein Atoll would not exceed permanent injury thresholds for consultation organisms and is below the temporary hearing effect thresholds (TTS) as well. The maximum noise levels for sonic booms may exceed the behavioral disturbance threshold for consultation organisms near the surface. However, these sounds would dissipate rapidly with depth in the ocean but animals near the surface may be exposed to sound sounds loud enough to cause temporary behavioral disturbance. The sonic boom footprint for sounds above 160 dB re 1 μPa would likely cover a large area around the flight path; however, the sound would last lest than 0.3 seconds. Because of the expected sound intensity loss at the air-water interface, the rapid attenuation of the sound in water, and the short duration of the sound, the low intensity sonic boom noise is expected to have insignificant effects on UES-listed cetaceans, sea turtles, and fish in the Action Area. As NMFS concluded in their 2015 BO for MMIII activities, "at most, an exposed individual may experience temporary behavioral disturbance in the form of slight changes in swimming direction or speed, feeding, or socializing, that would have no measurable effect on the animal's fitness, and [animals] would return to normal within moments of the exposure. Therefore, [...] exposure [to sonic boom noise] is expected to have insignificant effects" on consultation species (NMFS 2015a).

Effects of RV Impact Noise. For RV impacts in KMISS or the Vicinity of Illeginni Islet waters, sound pressure levels may peak at up to 250 dB re 1 μPa at impact and would last no more than a couple of seconds. Using a spherical spreading model for deep ocean waters (detailed in USAF 2015, NMFS 2015a, U.S. Navy 2019, NMFS 2019) the range to pressure effect thresholds from RV impact was calculated for UES consultation species groups (**Table 4-3).**

This is a simplified and conservative approach, as it does not account for differential sound attenuation due to ocean conditions such as water depth, temperature, salinity, or stratification.

The sound pressures from RV impact would exceed the PTS or non-auditory injury thresholds for consultation species but only very close to the impact point (**Table 4-3**). Sound pressures would also exceed the TTS thresholds out 20 to 501 m (65 to 1,644 ft) from impact for cetaceans and sea turtles, and up to 1,585 m (5,200 ft) for fish (**Table 4-3**). RV impacts in the Vicinity of Illeginni Islet would in deep waters approximately 790 m (2,600 ft) southwest of Illeginni Islet and approximately 470 m (1,540 ft) from the outer edge of the fringing reef (NMFS 2015a). Therefore, maximum sound levels in reef habitats would be less than 196 dB re 1 µPa.

Table 4-3. Maximum Underwater Radial Distance to Elevated Sound Pressure Level Effect Thresholds for UES Consultation Species from GBSD RV Ocean Impact.

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

Abbreviations: µPa = micropascals, dB = decibels, ft = feet, km = kilometers, m = meters, mi = miles, PTS = Permanent Threshold Shift, SEL = Sound Exposure Level, RMS = root mean squared, SPL = Sound Pressure Level, TTS = Temporary Threshold Shift

Density data are not available for UES-consultation cetaceans, sea turtles, and fish species in deep ocean waters of Kwajalein Atoll. However, if maximum density data for these species in other areas of the central Pacific Ocean (detailed in U.S. Navy 2019 and Hanser et al. 2017) are used, the number of expected injury, PTS, and TTS exposures for all species is substantially less than one. For example, around the Hawaiian Islands, the island stocks of pantropical spotted dolphins have maximum density estimates of 0.061 per square kilometer (km^2) (Hanser et al 2017), which would likely be on the very upper end of density for any cetacean species at

Kwajalein Atoll. Using this density, the estimated number of exposures to PTS would be only 0.00002 individuals for each impact and only 0.00006 potential TTS exposures per impact. Using green sea turtle density estimates for offshore waters of Guam of 1 per 3.4 km^2 (U.S. Navy 2015), there might be 0.00008 individual turtles exposures per impact to sounds above the PTS threshold and 0.00029 exposures to sounds above the TTS threshold. These examples provide an estimate of the maximum number of exposures for UES-consultation species in deep ocean waters of Kwajalein Atoll. Even if summed across the maximum of nine tests per year with up to three RVs per test, the number of individuals that might be exposed to pressures high enough to cause PTS or TTS is still estimated to be substantially less than one per year for these species and less than one over the proposed six years of the GBSD Test Program.

It is more likely that at some UES consultation species would be exposed to sound pressures above the behavioral disturbance thresholds and that some individuals may respond to the RV impact noise. However, as concluded by NMFS for the MMIII action (NMFS 2015a), any effects of this single impulsive noise are expected to “be limited to a temporary behavioral modification in the form of slight changes in swimming direction or speed, feeding, or socializing, that would have no measurable effect on the animal's fitness, and would return to normal within moments of the exposure.” Therefore, exposure to elevated sound pressures from RV impact in deep ocean waters is expected to have insignificant effects on UES consultation cetaceans, sea turtles, and fish in the Action Area.

As for other test programs, acute and temporary acoustic exposures such as those associated with RV impact would be expected to cause, at most, temporary consequences for some of the more specialized marine invertebrates (U.S. Navy 2019). While temporary disruption of feeding or predator avoidance behaviors (Mooney et al. 2010) in some invertebrates such as mollusks are possible, any exposed UES-listed corals or mollusks in nearshore reefs are expected to be unaffected by payload impact noise (NMFS 2019). As concluded by NMFS for the FE-2 action (NMFS 2019), noise associated with GBSD testing would have no effects on UES-listed corals and mollusks.

Effects of Vessel Noise. Noise from vessel operation would likely range from 150 to 190 dB re 1 µPa depending on the vessel type (NMFS 2019). Vessels would be moving and sounds would be continuous. While some marine mammals, sea turtles, or fish might be exposed to sounds loud enough to cause behavioral disturbance, the low intensity noise would at most cause temporary disturbance such as changes in swimming direction or speed, feeding, or socializing, that would have no measurable effect on the individual fitness (NMFS 2019). Animals would be expected to return to normal behaviors after the vessel passed and the noise is expected to have insignificant effects on UES-listed cetaceans, sea turtles, and fish in the Action Area. Vessels noise is expected to have no effect on UES-listed corals or mollusks.

Effects of Human Activity and Equipment Operation. Pre-test and post-test human activity and equipment operation is planned only in terrestrial areas. Because of the substantial loss of noise intensity at the air-water interface, little if any, increase in noise would occur in the marine environment as a result of these activities. If nesting or hauled-out sea turtles were present on

Illeginni Islet, noises from human activity and equipment operations might disturb individuals. However, no sea turtle nesting or haul-out activity has been observed on Illeginni Islet in over 20 years and effects are discountable.

If debris were to enter nearshore waters (less than 30 m or 100 ft deep), debris would be manually recovered and would involve heavy equipment if necessary. Noise generated by human activity and equipment operation in the marine environment would have the potential to cause behavioral disturbance UES-listed animals. Behavioral disturbance would likely be limited to temporary behavioral modification such as leaving the area of human activity and equipment operation or cessation of feeding activity. Cleanup activities would likely last no more than a couple of weeks. Animals would be expected to return to normal distributions and behaviors after cessation of the noise producing activities and are not likely to be adversely affected by noise produced by human activity and equipment operation.

4.2 Exposure to Direct Contact or Shock Waves

4.2.1 Direct Contact and Shock Wave Stressors

The Proposed Action would result in impact of RVs either on land at Illeginni Islet or in deeper ocean waters of Kwajalein Atoll.

In the deep ocean waters of KMISS or in the Vicinity of Illeginni Islet, RV impact would result in the RV impacting the ocean at high velocity. In addition to posing a direct contact risk, the RV impact would generate underwater shock/sound waves. These in-water pressures are discussed and evaluated in **Section 4.1**, *Exposure to Elevated Noise Levels* and are expected to have a larger area of potential effect than the contact area of the RV itself. RV impact in these deep ocean waters would not result in ground borne shock waves strong enough to injure corals or other organisms.

At Illeginni Islet, impact of the RV would directly impact terrestrial habitats and would have the potential to directly contact consultation organisms on land. The force of RV impact land would result in crater formation and may result in ejecta and/or shock waves radiating out from the point of impact. Empirical evidence from MMIII RV impact cratering and shock waves are used as estimates for the proposed GBSD Action. Craters from MMIII RV land impacts have been documented to be 6–9 m (20–30 ft) in diameter and 2–3 m (7–10 ft) deep (USAF 2015).

Upon impact, crater formation would result in natural substrate (i.e., soil and coral rubble) being ejected around the rim of the crater. For MMIII, ejecta resulting from crater formations was estimated to extend no more than 60 to 91 m (200 to 300 ft) from the impact location (USAF 2015, U.S. Navy 2019). Based on observations from MMIII and other payload testing at Illeginni Islet, most of the RV materials and substrate ejecta would remain close to edge of the crater and the density of ejecta would be expected to decrease with distance from the impact point (USAF 2015). The RV impact target area on Illeginni Islet includes only terrestrial areas. A shoreline payload impact is unplanned and unexpected for the GBSD Action but a land RV impact near the shoreline could result in the dispersal of soil and rubble onto the shallow nearshore reef flat (USAF 2015). For MMIII the USAF estimated that the probability of a shallow water impact was between 0.1 and 0.2 (USAF 2015).

Since a nearshore or shoreline strike is not expected, most of the ejected debris would fall on land. However, since the exact impact location and distribution of ejecta is unknown, these analyses assume a worst-case scenario of a shoreline RV impact where the ejected debris could enter the nearshore marine environment, similar to the approach used for MMIII analyses (USAF 2015). Although the exact shape of the potential debris field is unknown, 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 4-2**). Based on the worst-case scenario, ejected debris has the potential to occur in a 13,008 square meter (m^2; 15,557 square yard [yd^2]) area.

For MMIII tests, shock waves resulting from payload impact were estimated to be strong enough to damage corals out as far as 37.5 m (123 ft) from the point of impact (USAF 2015). If impact occurred on the shoreline, shock waves would propagate into the submerged seafloor (USAF 2015). No shoreline impact is planned or expected for GBSD testing; however, is assumed that shock waves strong enough to damage corals might propagate up to 37.5 m (123 ft) into the marine environment (**Figure 4-2**).

For high fidelity RV tests, the energy released at impact is expected to be an order of magnitude less than that of a non-high fidelity test RV because energy would be released during the airburst. Therefore, the shock wave, cratering, and debris field would not change appreciably when compared to a non-high fidelity test RV impact (USAF 2015).

4.2.2 Effects of Direct Contact and Shock Waves

Effects of RV Impact in Deep Ocean Waters. As discussed in **Section 4.1.2**, *Effects of Elevated Noise Levels*, if maximum density data for UES-consultation species in other areas of the central Pacific Ocean are used, the number individuals expected to be exposed to direct contact would be substantially less than one. Even if summed across the maximum of nine tests per year with up to three RVs per test and summed across the proposed 6 years of testing, the number of individuals that might be exposed to direct contact is still estimated to be substantially less than one. Therefore, the effects of direct contact from vehicle components on consultation cetaceans, sea turtles, and fish in deep water areas is discountable.

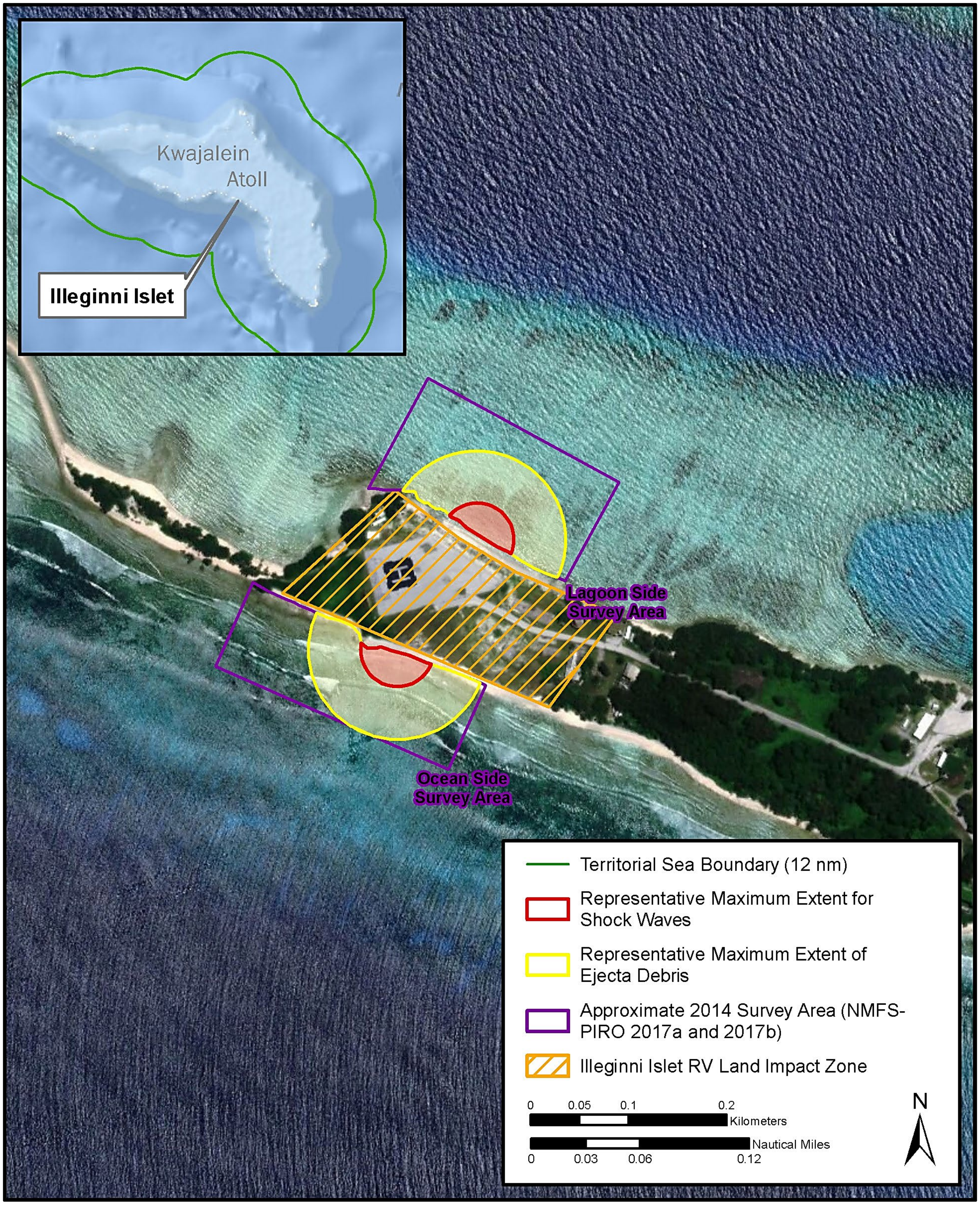


Figure 4-2. Representative Maximum Ejecta Debris Extent and Maximum Shock Wave Extent for a Shoreline RV Impact at Illeginni Islet.

Effects of RV Impact on Illeginni Islet. For up to three total tests, an RV may impact on land at Illeginni Islet. Test RV components would directly impact terrestrial habitats and have the potential to directly contact consultation organisms. Payload impact on land may also result in ejecta and shock waves radiating out from the point of impact. Only terrestrial and nearshore marine areas are at risk from direct contact and shock waves due to payload impact. No UES-listed cetaceans or deep-water fish species would be in the area of potential direct contact. Therefore, there would be no effect of direct contact on cetaceans or deeper-water fish species.

No UES-consultation species would be at risk from crater formation; however, the potential exists for shoreline and nearshore reef-associated species to be at risk from debris being ejected from the crater and by shock waves radiating out from the point of impact.

Terrestrial Habitats. While sea turtles hauled out or nesting on land and sea turtle nests have the potential to be adversely affected if struck by a piece of debris ejected during crater formation, no sea turtle nesting activity has been recorded on Illeginni Islet in over 20 years. Therefore, it is considered extremely unlikely that sea turtles would be in terrestrial habitats on Illeginni Islet and it is discountable that sea turtles would be adversely affected by direct contact or shock waves. As an additional avoidance measure, Illeginni Islet would be surveyed for sea turtle nesting and haul-out activity prior to the flight tests as described in **Section 2.3**, *Avoidance, Minimization, and Mitigation Measures*.

Direct Contact in Nearshore Marine Habitats. Corals, mollusks, humphead wrasses, and sea turtles have the potential to be adversely affected if struck by a piece of debris ejected during crater formation. Larger pieces of debris could crack or break parts of coral colonies or injure individual mollusks or fish.

As discussed in **Section 4.2.1**, empirical observations after RV or payload impact on Illeginni Islet for previous tests found that most of the test debris was contained within or near the crater rim (USAF 2015) and the density of falling material ejected during crater formation decreases with distance from the impact point (U.S. Navy 2017). The exact dispersion of test RV debris and ejecta is unknown but it is assumed that the primary ejecta debris would be natural substrate (crushed coral) ejected from the crater. It is also assumed, as a worst-case scenario, that half of the ejecta might enter the marine environment in the event of a shoreline impact. Under those assumptions and others listed in **Section 4.2.1**, ejecta debris might impact a maximum, non-contiguous area of 1,950 m^2 (2,332 yd^2). This is the total area that the natural debris might cover, but the debris would be in pieces and dispersed across a larger area (potentially out 91 m or 300 ft from impact) with debris density decreasing as distance from impact increases.

Since debris may disperse as far as 91 m (300 ft) from the point of impact, the marine area of potential direct contact is approximately 13,008 m^2 (15,557 yd^2) in a half circle extending out from the shoreline (**Figure 4-2**). Only a portion of the area of potential direct contact effect offshore of the Illeginni Islet impact area is suitable habitat for UES-consultation species. Based on the 2014 NMFS surveys of the area offshore of the RV land impact zone and the best professional judgment of NMFS survey divers, approximately 80% of the lagoon-side survey area (**Figure 4-2**) and 75% of the ocean-side survey area are considered potentially viable habitat for consultation coral, mollusk, and reef-associated fish species (NMFS 2019). Using these estimates of suitable habitat and assuming the ejecta would be on only one side of the islet for a given test (i.e., either on the lagoon or ocean sides of the islet); the area of lagoon-side and ocean-side suitable habitat which may be impacted by debris was calculated (**Table 4-4**). Using these percentages of suitable habitat likely results in an overestimate of the area of potential effect because habitat suitability for consultation species is lowest along the water's edge (where debris is more likely to occur) and with the exception of sandy patches, typically increases with distance from shore (NMFS 2019).

Table 4-4. Estimated Marine Areas with the Potential to be Impacted by RV and Ejecta Debris from a Shoreline Impact.

Parameter	Ocean Side	Lagoon Side
Total marine area of potential direct contact	13,008 m^2 (15,557 yd^2)	13,008 m^2 (15,557 yd^2)
Percent suitable habitat in NMFS survey area	75 percent	80 percent
Estimated area of suitable habitat potentially exposed to ejecta debris for worst case scenario	9,756 m^2 (11,668 yd^2)	10,406 m^2 (12,445 yd^2)

Abbreviations: m^2 = square meters, NMFS = National Marine Fisheries Service, yd^2 = square yards

Based on the estimated area of suitable habitat that ejecta might cover in the marine environment, the number of potential coral and mollusk exposures to direct contact was calculated based on the density of coral colonies and mollusks reported by NMFS in 2017 (NMFS-PIRO 2017a, 2017b) (**Table 4-5**). For a lagoon-side shoreline impact, an average of 2,935 coral colonies and three mollusks might be exposed to direct contact (**Table 4-5**). An average of 1,675 coral colonies and 24 mollusks might be exposed to direct contact for an ocean-side impact. If it is assumed that each potential test involving land impacts would have a shoreline impact (a worst-case scenario) and each would expose different marine areas to debris, an estimated 13,827 UES-consultation coral colonies and 71 individual mollusks might be exposed to direct contact from debris (**Table 4-5**) based on mean densities in the area.

As described by NMFS in their 2019 BO for the FE-2 action, the response of corals to exposure to ejecta and ground borne shock waves would depend on the scale and intensity of the exposure as well as on the morphology of the coral (NMFS 2019). Plate forming corals such as *Acropora microclados* are more easily broken than large massive or encrusting forms such as *Pavona venosa* (NMFS 2019). *Pocillopora meandrina* forms fairly compact bushy colonies with flattened branches radiating out (Center for Biological Diversity 2018), while *Heliopora coerulea* colony growth forms are highly variable depending on habitat (Sakashita and Wolf 2009). Not all corals exposed to debris would be damaged, but the most likely realized effects would be broken branches or plates or damaged soft tissue. Based on the expected dispersion pattern of the debris and lack of suitable coral habitat near the shoreline, complete pulverization of coral colonies is not likely.

Table 4-5. Estimated Numbers of Consultation Coral Colonies and Individual Mollusks Potentially Exposed to Debris Generated by GBSD RV Shoreline Impact.

Species	Ocean Side Single Test				Lagoon Side Single Test				Estimated Total Number of Colonies or Individuals Exposed for All Three Tests Involving Land Impact[1]
	Mean Colonies or Individuals (per m²)	99% UCL (per m²)	Potentially Affected Habitat (m²)	Number of Colonies or Individuals (mean to UCL)	Mean Colonies or Individuals (per m²)	99% UCL (per m²)	Potentially Affected Habitat (m²)	Number of Colonies or Individuals (mean to UCL)	
Corals									
Acropora microclados	0.0004	0.0017	9,756	4 to 17					12
Acropora polystoma	≤0.0004	0.0017	9,756	4 to 17					12
Cyphastrea agassizi					0.0003	0.0013	10,406	3 to 14	9
Heliopora coerulea					0.16	0.45	10,406	1,665 to 4,683	4,995
Pavona venosa					0.0003	0.0013	10,406	3 to 14	9
Pocillopora meandrina	0.3	0.58	9,756	2,927 to 5,658					8,781
Turbinaria reniformis					≤0.0003	0.0013	10,406	3 to 14	9
Coral Subtotal				**2,935 to 5,692**				**1,674 to 4,725**	**13,827**
Mollusks									
Hippopus hippopus	0.0003	0.0015	9,756	3 to 15	0.002	0.006	10,406	21 to 62	62
Tectus niloticus					0.00006	0.0003	10,406	1 to 3	3
Tridacna squamosa					0.0002	0.0011	10,406	2 to 11	6
Mollusk Subtotal				**3 to 15**				**24 to 76**	**71**

Notes: The species in this table include those found during a 2014 assessment of the reef areas offshore of the Illeginni Islet Impact Zone (NMFS-PIRO 2017a and 2017b). Coral colony and individual mollusk mean densities and 99% UCL provided by NMFS-PIRO (2017a and 2017b).
[1] The estimated total number of colonies or individuals exposed for all three tests with land RV impact was calculated based on the maximum mean density of colonies or individuals exposed during a single test multiplied by three.

Abbreviations: m² = square meter, UCL = upper confidence limit

Partial fracturing of a coral colony skeleton and contact from debris would injure the soft, living tissues of those portions of the colony. Coral have the potential to regrow after damage but regrowth and stress could still have a negative impact on growth rate, reproduction, and disease susceptibility (NMFS 2019). The break could expose the coral to threats from algae or sponge growth infection by diseases that may prevent regrowth (NMFS 2019). As detailed by NMFS (2019), since these corals are colonial organisms with hundreds to thousands of genetically-identical interconnected polyps, affecting some polyps of a colony does not necessarily constitute harm to the individual (defined as a colony) as the colony can continue to exist even if the colony is damaged.

Smaller, sand-like particles would remain close to the point of impact and resulting crater. Since the worst-case scenario would be a shoreline impact, sand-like debris would only occur in areas very near the shore where corals do not occur or density is very low. Therefore, corals and mollusks are not likely to be buried by or have their soft tissues scoured by large amounts of small payload ejecta.

Direct contact may affect, and in the event of a shoreline strike, is likely to adversely affect seven UES-consultation coral species (*Acropora microclados*, *A. polystoma*, *Cyphastrea agassizi*, *Heliopora coerulea*, *Pavona cactus*, *Pocillopora meandrina*, and *Turbinaria reniformis*) and three UES-consultation mollusk species (*Hippopus hippopus*, *Tectus niloticus*, and *Tridacna squamosa*) (**Table 4-5**). The estimates for the number of colonies or individuals exposed to direct contact are considered maximum estimates of effects for the following reasons:

- Shoreline RV impacts are not planned and the amount of debris entering the water would decrease as land impact distance from shore increased.
- Exposure calculations assume that all three tests involving RV land impacts would result in a shoreline impact and that all three tests would result in impact debris in a different marine location, which is highly unlikely to occur.
- Exposure calculations assume that the entire area with potential for ejecta debris would be covered with debris when in reality debris would be dispersed outward from the impact point with decreasing density as distance increases.
- Ejected debris would be most likely near the water's edge where habitat suitability for consultation corals is lowest (NMFS 2019). Therefore, calculations based on suitable habitat for the whole survey area are likely overestimates of potential effect for these species.
- NMFS has indicated that the distribution and density reports likely overestimated the number of coral and mollusk species that may be within the area of potential effect at Illeginni Islet (NMFS 2019). Therefore, calculations based on these density data are likely overestimates of potential effect.

- Exposure to shock waves or ejecta from payload impact would probably be limited to cracks and or loss of branches (as opposed to pulverizing the entire colony). Any cracking or loss of branches would likely injure or destroy soft tissue; however, it would not necessarily result in mortality of the colony.

Humphead wrasses have the potential to be injured if exposed to direct contact from debris; however, several factors make this unlikely. No humphead wrasse were observed in the 2014 surveys of the areas offshore of the Illeginni Islet impact area. This is a highly mobile species recorded in nearby habitats and up to 8 adult and 100 juvenile humphead wrasses were projected to in the area of potential effect for previous missile testing at Illeginni (NMFS-PIRO 2017a). However, humphead wrasses and are generally not found at the surface (NMFS 2019) where they would be most vulnerable to effects from direct contact. These fish are most commonly found in waters a few meters to at least 60 m (197 ft) deep (NMFS 2019) and any debris would rapidly loose velocity upon entering the water. In addition, NMFS stated that the humphead wrasses observed near Illeginni Islet have been observed beyond the reef crest around 91 m (300 ft) from the shoreline (NMFS 2019). It is unlikely that any humphead wrasse would be contacted by ejecta. While considered unlikely, any effects from debris entering the water would be limited to temporary behavioral responses. Fish would be expected to return to normal behaviors within moments of exposure. Debris is expected to have insignificant effects on UES-listed fish in the Action Area.

Sea turtles are very unlikely to be in marine areas where ejecta might land. Green and hawksbill turtles may occur infrequently around Illeginni Islet, but they would occur in low numbers and are typically found in waters near the reef edge, which is over 150 m (500 ft) from the shore (NMFS 2019). Even if turtles were in waters closer to the shore where they might be exposed to ejecta sinking to the bottom, the ejecta would be fairly slow moving after entering the water and any effects would be likely be limited to temporary behavioral disturbance. Sea turtle behavior would return to normal within moments of exposure with no measurable fitness effects (NMFS 2019). As with debris in terrestrial areas, ejecta in the marine environment would have insignificant effects on sea turtles.

Shock Waves in Nearshore Marine Habitats. Shock waves have the potential to crack or fragment corals depending on the intensity of the shock wave and the morphology of the coral. For previous tests, shock waves resulting from payload impact that were strong enough to damage corals were estimated to extend as far as 37.5 m (123 ft) from the point of impact if on the shoreline (U.S. Navy 2019). No shoreline impact is planned for the GBSD tests. Therefore, for nominal tests, shock waves intense enough to damage corals would not propagate that far into the marine environment and would be less intense in the marine environment. If the worst-case scenario of a shoreline RV impact is considered, coral colonies might be exposed to shock waves. As discussed above, habitat suitability for consultation species is lowest along the water's edge (where shock waves would be most intense) and typically increases with distance from shore (NMFS 2019).

As described by NMFS in their 2019 BO for the FE-2 action, the response of corals to exposure to ejecta and ground borne shock waves would depend on the morphology of the coral with plate forming corals being more easily broken than large massive or encrusting forms (NMFS 2019). The UES-consultation coral species which would be most sensitive to shock waves would be those with branching or corymbose colonies including *Acropora microclados*, *Acropora polystoma*, and *Pocillopora meandrina*, and the plate-like *Turbinaria reniformis*. *Cyphastrea agassizi* and *Pavona venosa*, massive-type corals, would be least affected by shock waves.

If shock waves strong enough to damage corals might extend out 37.5 m (123 ft) from impact, shock waves might occur in approximately 2,209 m^2 (2,642 yd^2) of nearshore marine areas. In the event of a shoreline RV impact, it is likely that some coral colonies would be affected, but the most likely realized effects would be cracks in the colony or broken branches or plates. As discussed for direct contact above, fracturing or broken branches would injure the soft tissue near the break but affecting some polyps of a colony does not necessarily constitute harm to the individual as the colony can continue to exist even if the colony is damaged.

Since the maximum debris exposure and potential shock wave exposure areas overlap (**Figure 4-2**) and since harmed individuals should be counted only once in determining the effects of the Proposed Action, the effects on nearshore coral species were calculated based on the potential debris exposure area. No additional coral colonies would be exposed to ground-borne shock waves that were not already included in the potential effects of direct contact by debris or ejecta (**Table 4-5**).

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

Humphead wrasses have the potential to be injured by the concussive shock waves; however, several factors make this highly unlikely for the Proposed Action. The shock waves would propagate primarily through the substrate, and it can be assumed that little of the pressure intensity would be transferred to the water. Therefore, the range of onset of significant injuries to fish from shock waves is likely substantially less than for corals (NMFS 2019). In addition, NMFS stated that the humphead wrasses observed near Illeginni Islet have been observed beyond the reef crest around 91 m (300 ft) from the shoreline (NMFS 2019). As with elevated noise levels discussed in **Section 4.1.2**, any realized effects of shock waves on nearshore fish, including the humphead wrasse, would likely be limited to temporary behavioral responses. Fish would be expected to return to normal behaviors within moments of exposure to shock wave pressures and the shock waves are expected to have insignificant effects on UES-listed fish in the Action Area.

4.3 Exposure to Hazardous Materials

4.3.1 Hazardous Material Stressors

The Proposed Action has the potential to introduce hazardous materials into the Action Area. Impact of the payload would have the potential to introduce propellants, battery acids, and heavy metals into the terrestrial or marine environment at the impact site. The test RVs do not contain any fissile materials. However, based on the composition of MMIII RVs (detailed in **Table 2-1**), the test RVs would likely contain varying quantities of hazardous materials, potentially including batteries, explosives, asbestos, DU, and other heavy metals.

Following an RV impact in the KMISS or Vicinity of Illeginni Islet waters, fragmentation of the RV would disperse any onboard hazardous materials, such as Be and DU, around the impact point. Be and DU fragments are highly insoluble (i.e., they dissolve extremely slowly) (USAF 2015). Dilution and mixing in the ocean water occurs much faster than dissolution of Be and DU; therefore, their concentrations in seawater would likely be indistinguishable from natural background levels (USAF 2015). RV components would sink relatively quickly to the ocean floor and would not be recovered in waters greater than 30 m (100 ft) deep.

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

Several avoidance, minimization, and mitigation measures would be in place to reduce the potential for effects due to hazardous materials (listed in **Section 2.3**) including post-test soil and groundwater sampling for hazardous materials.

4.3.2 Effects of Exposure to Hazardous Materials

For all species considered in this BA, exposure to hazardous materials as a result of the Proposed Action would have insignificant effects. Several avoidance and minimization measures would be in place as part of the Proposed Action to minimize the potential for hazardous material to affect biological resources (**Section 2.3**). Considering the planned cleanup of man-made materials, the very small quantities of hazardous materials expected to be introduce to terrestrial and marine habitats, and the dilution and mixing capabilities of the ocean and lagoon waters, materials released during RV impact would not be present in sufficient quantities or concentrations to adversely affect any consultation cetacean, fish, sea turtle, or invertebrate in the Action Area. The effects of hazardous materials on UES-consultation species would be insignificant.

4.4 Human Activity and Equipment Operation

4.4.1 Human Activity and Equipment Operation Stressors

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

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

In the Vicinity of Illeginni Islet, human activity would involve pre-test deployment and post-test recovery of sensory rafts as well a possible post-test RV recovery and cleanup. RVs typically strike waters in the Vicinity of Illeginni at a distance of approximately 792 m (2,600 ft) from shore. For nominal missions in general, RV recovery is not attempted in deeper waters on the ocean side of Illeginni Islet. However, if necessary, searches for debris would be attempted to depths of 50–100 ft (15–30 m) (USAF 2015). A ship would be used for recovery and a remotely operated vehicle would be used to locate the debris field on the bottom before scuba divers would attempt to recover the debris manually (USAF 2015). Divers would be briefed prior to operations about coral fragility and provided guidance on how to avoid or minimize unavoidable contact with fragile marine resources as they carefully retrieve the very small pieces of RV debris that they would be looking for (USAF 2015).

Elevated levels of human activity are expected for several weeks at Illeginni Islet. During this period, several vessel round-trips are likely. Helicopters would also be used to transport equipment and personnel to Illeginni Islet. Personnel and equipment would be used for preparation of the impact site including placement of cameras and other sensors in both terrestrial areas. Sensor rafts with onboard optical or acoustic sensors would be deployed by landing craft utility in the lagoon or ocean waters within approximately 792 m (2,600 ft) of the islet in waters no less than 3 m (10 ft) deep. Post-flight cleanup would involve recovery of all man-made test debris possible and would include personnel and equipment use in terrestrial habitats. Man-made debris would be removed from the impact crater and it would be filled with surrounding substrate that was ejected from the crater. These post-test activities may include use of heavy equipment such as a backhoe or grader.

Post-test human activity in marine areas near Illeginni Islet would likely only involve vessel traffic to and from Illeginni Islet and collection of sensor rafts. Use of heavy equipment in the nearshore marine environment is not expected since shallow water and reef habitats would not be targeted. However, if test debris enters the nearshore marine environment, including the reef flat, test personnel may manually recover debris. Human activity in the nearshore marine environment would be limited to the area near the RV land impact where debris entered the water. In the event of an unexpected shoreline or reef-flat payload impact, several measures and procedures would be in place (**Section 2.3**) to guide post-test activities in order to avoid impacts to consultation organisms. If divers are required to search for RV debris on the adjacent reef flat, they would be briefed prior to operations about coral fragility and provided guidance on how to carefully retrieve the very small pieces of RV debris that they would be looking for.

4.4.2 Effects of Human Activity and Equipment Operation

Most of the human activities and equipment operation related to the Proposed Action would take place in terrestrial environments. The only UES-consultation organisms with the potential to be affected by human activity and equipment operation on Illeginni Islet are hauled out or nesting sea turtles. Several mitigation measures would be in place as part of the Proposed Action to minimize the chance of affecting sea turtles, including sea turtle nest and activity searches of suitable habitat at Illeginni Islet leading up to the test. As discussed in **Section 3.2**, no sea turtle nests or nesting activity have been observed on Illeginni in over 20 years. Sea turtle nest pits (unidentified species) were last found on Illeginni Islet in 1996, on the northern tip of the islet. Therefore, it is considered discountable that any sea turtles or sea turtle nests would be exposed to human activity and equipment operation in terrestrial habitats.

Planned human activity and equipment operation in marine areas would only involve vessel traffic to and from Illeginni Islet and use of sensor rafts. No debris recovery or other cleanup activities are expected to be required in shallow nearshore waters. In the event that debris entered the nearshore marine environment, several measures would be in place to protect reef habitats and consultation species (**Section 2.3**). During planned test activities, nearshore reef-associated species including corals and mollusks would not be affected by human activity and equipment operation. For other motile cetacean, sea turtle, and fish species, response to Proposed Action human activity and equipment operation would likely be limited to short-term behavioral reactions such as avoidance behavior. This type of response is not expected to have any measurable effect fitness of individuals and animals would be expected to return to normal behaviors within minutes of cessation of activity. Human activity and equipment operation is expected to have insignificant effects on UES-listed cetaceans, sea turtles, and fish in the Action Area.

4.5 Vessel Strike

4.5.1 Vessel Activity Stressors

The Proposed Action has the potential to increase ocean-going vessel traffic in Kwajalein Atoll for several weeks. Pre-test activities would include several vessel round-trips to and from Illeginni Islet or the Vicinity of Illeginni Islet for personnel and equipment transport. Sensor rafts would also be deployed from a vessel near either of these impact sites. Post-test recovery efforts would also result in increased vessel traffic to Illeginni Islet or the Vicinity of Illeginni Islet. Vessels would be used to transport heavy equipment (such as backhoe or grader) and personnel for manual cleanup of debris, backfilling or any craters, and instrument recovery. Deployed sensor rafts would also be recovered by a vessel.

No increased vessel traffic would occur for RV impacts in the KMISS area.

4.5.2 Effects of Vessel Strike

Consultation organisms have the potential to be affected by vessel strike primarily by being at the surface when a vessel travels through an area. Organisms at the surface, such as cetaceans and sea turtles that must surface to breath air, are at risk of being struck by vessels or their propellers. Several measures would be in place to reduce the chances of a cetacean or sea turtle being struck by a vessel (**Section 2.3**), including the requirement that vessel operators watch for and avoid marine protected species where possible based on ocean conditions. Based on the expected low density of cetaceans and sea turtles in the Action Area and implementation of avoidance measures, the risk of vessel strike for these species is considered discountable.

It is also discountable that vessels would strike UES-consultation fish in the Action Area. The fish species listed in **Table 3-1** are agile animals capable of avoiding oncoming vessels and are only infrequently found near the ocean surface since they do not need to surface to breathe (NMFS 2019). The Proposed Action would involve no anchoring (vessels would use Illeginni Harbor); therefore, vessels and anchors would not contact the substrate and would have no effect on UES-consultation invertebrates.

5.0 CUMULATIVE EFFECTS

Cumulative effects include the effects of future state, tribal, local, or private actions that are reasonably certain to occur in the Action Area. These types of actions that are reasonably certain to occur in the Action Area have not changed since preparation of the FE-2 BA (U.S. Navy 2019), and the description of these activities in the FE-2 BA is incorporated here by reference. Future federal actions that are unrelated to the Proposed Action are not considered in the cumulative effects section of BAs as they require their own separate consultation pursuant to Section 7 of the ESA. Therefore, the analysis of cumulative effects for the Proposed Action considers the effects of the GBSD test activities at Kwajalein Atoll and the activities and considerations in section 6.0 of the FE-2 BA (U.S. Navy 2019) as summarized in **Table 5-1**.

Table 5-1. Future Actions and Other Environmental Considerations Identified for Cumulative Effects Analysis.

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

The foreseeable future actions and environmental considerations in the Action Area are described in section 6.1 of U.S. Navy 2019. This section evaluates the cumulative effects of these considerations along with the proposed GBSD test activities on consultation species.

5.1 Cumulative Effects on Marine Mammals

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

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

Based on analyses in **Section 4.0**, *Effects of the Proposed Action*, marine mammals are not likely to be adversely affected by Proposed Action activities in the Action Area. It is considered discountable that the Proposed Action would affect cetaceans. Therefore, it is unlikely that proposed GBSD Test Program activities would contribute to or increase cumulative effects on marine mammals.

5.2 Cumulative Effects on Sea Turtles

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

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

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

Based on analyses in **Section 4.0**, *Effects of the Action*, sea turtles not likely to be adversely affected by Proposed Action activities in the Action Area. Sea turtles have low densities in the Action Area and it is not expected that proposed activities would contribute to or increase cumulative effects on sea turtles in marine or terrestrial habitats.

5.3 Cumulative Effects on Fish

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

Fish have the potential to be impacted by cumulative effects from commercial and recreational fishing, subsistence and artisanal fishing, vessel traffic, ocean pollution and marine debris, and climate change and ocean acidification. Commercial and recreational fishing are of concern to fish due to targeted fishing, bycatch, and changes in community composition. Overfishing and bycatch from commercial fishing is listed as one of the most serious threats leading to listing (or proposed listing) for all consultation fish in the Action Area (see **Appendix A**). Due to overharvest and bycatch, oceanic whitetip shark populations have decreased approximately 90% from 1996 to 2009 (Defenders of Wildlife 2015) and Pacific bluefin tuna populations have decreased to approximately 2.6% of their estimated unfished biomass (Center for Biological Diversity 2016). In the RMI, tuna comprise 90% of the annual catch from locally-based offshore fisheries and a majority of the foreign-based offshore fishing in the Marshall Islands Zone as well (FAO 2009). While subsistence and artisanal fishing in the RMI is a fraction of the total fish harvest in the Action Area, it affects UES consultation fish species and remains a consideration in cumulative effects. The Marshall Islands Marine Resource Authority (MIMRA) is responsible for both offshore and coastal fisheries in the Marshall Islands including a management plan for tuna with longline limits for bigeye tuna (FAO 2009). There are also regional efforts to limit the number of purse seine fishing days in Pacific Island countries (FAO 2009).

The effects of vessel traffic on fish is generally limited to causing avoidance behaviors; however, there is some evidence that juvenile fish might be affected by cavitation from a vessel's propeller movement or propeller wash. Ocean noise including elevated underwater sounds from vessels has the potential to impact fish through behavioral response, hearing loss, auditory masking, injury, and even mortality (U.S. Navy 2015). In the open ocean, chemical pollution is not generally an immediate threat to fish; however, increasing evidence of bioaccumulation of pollutants in fish and other organisms is a growing concern (U.S. Navy 2015). As with other organisms, fish can also become entangled in marine debris or can mistake debris for food and ingest it (U.S. Navy 2015). The effects of climate change and ocean acidification are likely to impact fish primarily by influencing prey availability and habitat suitability. Changing ocean temperatures may alter prey availability and distribution both in the open ocean and in nearshore areas. For reef associated species such as the humphead wrasse and the reef manta ray, changes in coral reef habitat can affect food availability, cover, and overall health and resilience of these fish. All of these environmental considerations are expected to continue in the foreseeable future and may have adverse impacts on fish populations, especially reef-associated species.

Based on analyses in **Section 4.0**, *Effects of the Action*, fish are not likely to be adversely affected by Proposed Action activities. UES-consultation fish species have low densities and patchy distributions in the Action Area and it is unlikely that proposed activities would contribute to or increase cumulative effects on fish.

5.4 Cumulative Effects on Corals and Mollusks

Consequences of cumulative impacts on corals and mollusks can manifest as any combination of loss of biomass or diversity, decreased resistance to disturbance, or decreased resilience following disturbance (e.g., delayed or lack of recovery from disturbance) (Connell 1997, Hughes and Connell 1999, Jaap 2000, Porter et al. 1999, Rogers and Garrison 2001). The USFWS/NMFS biological inventories have revealed relatively poor reef habitat conditions on the shallower northwestern ocean-side reef at Illeginni (USFWS and NMFS 2002, 2004, and 2006). This area is exposed to strong waves from the south and west and, more than other reefs at Illeginni Islet, is exposed to the effects of a variety of activities including past and ongoing missile tests, unexploded ordnance disposal, and aircrew training missions (USFWS and NMFS 2002, and 2006). The relatively poor habitat conditions observed on the shallow northwestern ocean-side portion of the Illeginni reef is more likely to be associated with the cumulative effects of USAG-KA activities and natural processes. Disentangling the consequences of individual causes of effects in marine systems is very difficult (Fabricius 2005, Nyström et al. 2008). Even if prior missile flight test impacts could not be parsed out, they were a likely contributor to the area's present condition.

Corals and mollusks have the potential to be impacted by cumulative effects from commercial and recreational fishing, subsistence and artisanal fishing, vessel traffic, ocean pollution and marine debris, and climate change and ocean acidification. Commercial and recreational fishing affect corals and mollusks through targeted fishing, bycatch, and habitat alteration. Part of the fisheries catch in the RMI includes non-food commodities such as mollusks, aquarium fish, and corals (FAO 2009). Exports from the coastal commercial fisheries are primarily aquarium fish and coral for U.S. markets and top shell snails for button factories in Asia and Europe (FAO 2009). The aquarium fishery operating at Majuro and Eniwetak Atolls supports most of the top shell snail catch (FAO 2009). While subsistence and artisanal fishing in the RMI is likely a small portion of the total coral and mollusk harvest in the Action Area, the fishery likely affects UES consultation species and remains a consideration in cumulative effects. MIMRA is responsible for coastal fisheries management in the Marshall Islands including a prohibition on taking *Tectus* (*Trochus*) except during a short open season (FAO 2009). Some fishing methods or marine debris created from abandoned fishing equipment can damage corals in reefs. Lost or abandoned traps, nets, and lines from fisheries can damage corals in reefs.

The main effect of vessel traffic on coral and mollusks is the effect of cavitation on larvae. Cavitation from vessels traveling through an area could lead to decreased fertilization, larval deformities, or even larval death (NMFS 2015b). Studies have provided evidence that larvae subject to highly turbulent water may die or have abnormal development (NMFS 2015b). While very little is known about the sensitivity of invertebrates to sound (Hawkins and Popper 2012), elevated sounds in the ocean have the potential to impact coral and mollusks. Many marine invertebrates are able to detect sounds (Hawkins and Popper 2012) and even coral larvae have been known to orient in response to acoustic cues in reefs (Vermeij et al 2010). In the open ocean, chemical pollution is not generally an immediate threat to coral and mollusk species; however, increasing evidence of bioaccumulation of pollutants in fish and other organisms is a growing concern (U.S. Navy 2015). As with other organisms, corals and mollusks can become entangled in or inadvertently ingest particles of marine debris. The effects of climate change and ocean acidification on corals is detailed in **Section 5.5**. Mollusks would be affected by many of the same factors, and any effects to corals that change reef dynamics or structure would also affect reef-associated mollusks. All of these environmental considerations are expected to continue in the foreseeable future and may have adverse impacts on fish populations, especially reef-associated species.

Based on analyses in **Section 4.0**, *Effects of the Action*, proposed activities either would not or are not likely to affect larval corals and mollusks or adults of several species of corals and mollusks. Adults of seven coral and three mollusk species have the potential to be damaged by direct contact or shock waves and these species may be adversely affected by the Proposed Action. The Proposed Action has the potential to affect a small number of corals and mollusks but would not change the regional population density, distribution, or recovery ability of these species and would not significantly contribute to cumulative effects on these species.

5.5 Cumulative Effects Related to Climate Change and Ozone Depletion

Solid propellant rocket motors release several chemicals and compounds which may contribute to climate change and ozone depletion. The main rocket exhaust products that can contribute to ozone depletion are hydrochloric acid (HCl) and alumina (Al_2O_3) (Ross et al. 2010). In the stratosphere, emissions of HCl react with oxygen to produce ozone-damaging chlorine oxides (Ross et al. 2009). Globally, rockets are becoming a serious concern with regard to ozone layer depletion (Ross et al. 2009). Alumina is another main exhaust product of rockets, but very little is known about ozone loss from alumina particles (Ross et al. 2009). Ross et al. (2009) report that "only alumina particles smaller than 1 μm remain in the stratosphere for years and contribute to the steady-state ozone loss. The fraction of [solid rocket motor] alumina particles that meet this criterion has been variously reported as between 1% and 30%."

The main rocket exhaust products that can contribute to climate change are carbon dioxide (CO_2) and soot or black carbon particulate (Ross et al. 2010). The effects of CO_2 on global warming are fairly well documented and some effects are outlined in section 6.1 of the FE-2 Biological Assessment (U.S. Navy 2019). Globally, annual emissions of CO_2 from rockets (several kilotons) are estimated to be a fraction of CO_2 emissions from aircraft (several hundred kilotons), which is only a few percent of the total annual CO_2 emissions from all sources (Ross et al. 2009). Particles emitted by rockets such as alumina, metallic debris, and soot or black carbon particulate, contribute to the radiative properties of the atmosphere by absorbing visible light (Ross et al. 2010). When sunlight enters the earth's atmosphere, black carbon absorbs visible light, subsequently warming the atmosphere. Toohey (n.d.) states that "it is estimated that black carbon emitted by rockets is over one million times more efficient at heating the atmosphere than an equivalent amount of CO_2 by weight." Black carbon in the lower atmosphere is removed within months by rain and dry deposition; however, black carbon can remain in the upper atmosphere for 5-10 years (Toohey n.d). Compared to aircraft, rockets emit several orders of magnitude more black carbon (per propellant) (Ross et al. 2010). The global rocket launch rate has more than doubled in the past decade (Ross and Toohey 2019). In 2018, rockets emitted about 225 tons of black carbon globally which is comparable to the amount emitted globally by aircraft (Ross and Toohey 2019).

While any individual rocket launch has a small contribution to climate change, taken together, rocket launches make up an increasing proportion of emissions (Ross and Toohey 2019) which should be considered in cumulative effects. Even at current launch rates, however, global quantities of gas emissions from rockets still remain a fraction of atmospheric inputs from other sources and do not significantly affect the global climate or ozone layer (Larsen et al. 2017).

While the cumulative effects of rocket launches on climate change and ozone depletion are real and have the potential to be serious, and the GBSD Test Program launches would produce emissions which would contribute to climate change and ozone depletion, the proposed GBSD Test Program flight tests are unlikely to significantly contribute to or increase the cumulative effects of climate change or ozone depletion.

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6.0 CONCLUSIONS

Based on analyses of all of the potential stressors in the Action Area, the USAF has determined that the Proposed Action would have “no effect” on 15 coral species (*Acanthastrea brevis*, *Acropora aculeus*, *A. aspera*, *A. dendrum*, *A. listeri*, *A. speciosa*, *A. tenella*, *A. vaughani*, *Alveopora verrilliana*, *Leptoseris incrustans*, *Montipora caliculata*, *Pavona cactus*, *P. decussata*, *Turbinaria mesenterina*, and *T. stellulata*)and two mollusk species (*Pinctada margaritifera* and *Tridacna gigas*) listed as consultation species under the UES (**Table 3-2**). These species are not known to occur in the portion of the Action Area where they might be exposed to stressors resulting from the Proposed Action.

The USAF has determined that the Proposed Action “may affect but is not likely to adversely affect” 16 cetacean species, two sea turtle species, and seven fish species listed as consultation species under the UES in the Action Area (see **Table 6-2**). The species that may be but are not likely to be adversely affected by the Proposed Action include the cetaceans *Balaenoptera musculus*, *B. physalus*, *Delphinus delphis*, *Feresa attenuata*, *Globicephala macrorhynchus*, *Grampus griseus*, *Kogia breviceps*, the Western North Pacific DPS of *Megaptera novaeangliae*, *Mesoplodon densirostris*, *Orcinus orca*, *Peponocephala electra*, *Physeter macrocephalus*, *Stenella attenuata*, *S. coeruleoalba*, *S. longirostris*, and *Tursiops truncatus*; the Central West Pacific DPS of green turtle (*Chelonia mydas*); the hawksbill turtle (*Eretmochelys imbricata*); and the fish *Alopias superciliosus*, *Carcharhinus longimanus*, *Cheilinus undulatus*, *Manta alfredi*, *M. birostris*, *Sphyrna lewini*, and *Thunnus orientalis*. Based on the analysis in **Section 4.0** and summarized in **Table 6-2**, the effects of the Proposed Action on these species would be insignificant or discountable.

The USAF has determined that the Proposed Action “may affect and is likely to adversely affect” seven coral species and three mollusk species (**Table 6-1**). The species likely to be adversely affected by the Proposed Action are the corals *Acropora microclados*, *A. polystoma*, *Cyphastrea agassizi*, *Heliopora coerulea*, *Pavona cactus*, *Pocillopora meandrina*, and *Turbinaria reniformis*; and the mollusks *Hippopus hippopus*, *Tectus niloticus*, and *Tridacna squamosa*. Based on the analysis presented in **Section 4.1**, the Proposed Action may adversely affect up to 13,827 coral colonies and 71 individual mollusks (**Table 6-2**).

There is no designated critical habitat for any listed species in the Action Area.

Table 6-1. Estimated Total Number of Consultation Coral Colonies and Individual Mollusks Potentially Adversely Affected by Proposed GBSD Activities.

Species	Estimated Total Number of Colonies or Individuals That May be Adversely Affected(1)
Corals	
Acropora microclados	12
Acropora polystoma	12
Cyphastrea agassizi	9
Heliopora coerulea	4,995
Pavona venosa	9
Pocillopora meandrina	8,781
Turbinaria reniformis	9
Coral Subtotal	**13,827**
Mollusks	
Hippopus hippopus	62
Tectus niloticus	3
Tridacna squamosa	6
Mollusk Subtotal	**71**

Note:
(1) The estimated total number of colonies or individuals that may be adversely affected for all three tests with land impact was calculated based on the mean density of colonies or individuals potentially exposed to direct contact from debris or shock waves.

Table 6-2. Effect Determinations for UES-Consultation Species that may be Affected by the Proposed Action. ("–"not known to be present in this portion of the Action Area, ○ = no effect, ◎=may affect but not likely to adversely affect, ●=may affect and likely to adversely affect)

Scientific Name	Common Name	Deep ocean waters of KMISS and in the vicinity of Illeginni Islet					Illeginni Islet and nearshore habitats				
		Elevated Sound	Direct Contact	Hazard. Materials	Human Activity	Vessel Strike	Elevated Sound	Direct Contact	Hazard. Materials	Human Activity	Vessel Strike
Cetaceans											
Balaenoptera musculus	Blue whale	◎	◎	◎	◎	◎	–	–	–	–	–
B. physalus	Fin whale	◎	◎	◎	◎	◎	–	–	–	–	–
Delphinus delphis	Short-beaked common dolphin	◎	◎	◎	◎	◎	–	–	–	–	–
Feresa attenuata	Pygmy killer whale	◎	◎	◎	◎	◎	–	–	–	–	–
Globicephala macrorhynchus	Short-finned pilot whale	◎	◎	◎	◎	◎	–	–	–	–	–
Grampus griseus	Risso's dolphin	◎	◎	◎	◎	◎	–	–	–	–	–
Kogia breviceps	Pygmy sperm whale	◎	◎	◎	◎	◎	–	–	–	–	–
Megaptera novaeangliae	Humpback whale (Western North Pacific DPS)	◎	◎	◎	◎	◎	–	–	–	–	–
Mesoplodon densirostris	Blainville's beaked whale	◎	◎	◎	◎	◎	–	–	–	–	–
Orcinus orca	Killer whale	◎	◎	◎	◎	◎	–	–	–	–	–
Peponocephala electra	Melon-headed whale	◎	◎	◎	◎	◎	–	–	–	–	–
Physeter macrocephalus	Sperm whale	◎	◎	◎	◎	◎	–	–	–	–	–
Stenella attenuata	Pantropical spotted dolphin	◎	◎	◎	◎	◎	–	–	–	–	–
S. coeruleoalba	Striped dolphin	◎	◎	◎	◎	◎	–	–	–	–	–
S. longirostris	Spinner dolphin	◎	◎	◎	◎	◎	–	–	–	–	–
Tursiops truncatus	Bottlenose dolphin	◎	◎	◎	◎	◎	–	–	–	–	–
Sea Turtles											
Chelonia mydas	Green turtle (Central West Pacific DPS)	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎
Eretmochelys imbricata	Hawksbill turtle	◎	◎	◎	◎	◎	◎	◎	◎	◎	◎

Scientific Name	Common Name	Deep ocean waters of KMISS and in the vicinity of Illeginni Islet					Illeginni Islet and nearshore habitats				
		Elevated Sound	Direct Contact	Hazard. Materials	Human Activity	Vessel Strike	Elevated Sound	Direct Contact	Hazard. Materials	Human Activity	Vessel Strike
Fish											
Alopias superciliosus	Bigeye thresher shark	◎	○	◎	◎	◎	–	–	–	–	–
Carcharhinus longimanus	Oceanic whitetip shark	◎	○	◎	◎	◎	–	–	–	–	–
Cheilinus undulatus	Humphead wrasse	–	–	–	–	–	◎	◎	◎	◎	◎
Manta alfredi	Reef manta ray	◎	◎	◎	◎	◎	◎	○	◎	◎	◎
M. birostris	Oceanic giant manta ray	◎	◎	◎	◎	◎	◎	○	◎	◎	◎
Sphyrna lewini	Scalloped hammerhead (Indo-West Pacific DPS)	◎	◎	◎	◎	◎	◎	○	◎	◎	◎
Thunnus orientalis	Pacific bluefin tuna	◎	○	◎	◎	◎	–	–	–	–	–
Corals											
Acropora microclados		–	–	–	–	–	○	●	◎	◎	○
A. polystoma		–	–	–	–	–	○	●	◎	◎	○
Cyphastrea agassizi	Agassiz's coral	–	–	–	–	–	○	●	◎	◎	○
Heliopora coerulea	Blue coral	–	–	–	–	–	○	●	◎	◎	○
Pavona cactus		–	–	–	–	–	○	●	◎	◎	○
Pocillopora meandrina		–	–	–	–	–	○	●	◎	◎	○
Turbinaria reniformis		–	–	–	–	–	○	●	◎	◎	○
Mollusks											
Hippopus hippopus	Giant clam	–	–	–	–	–	○	●	◎	◎	○
Tectus niloticus	Top shell snail	–	–	–	–	–	○	●	◎	◎	○
Tridacna squamosa	Giant clam	–	–	–	–	–	○	●	◎	◎	○

● = may affect and likely to adversely affect, ◎ = may affect but not likely to adversely affect, ○ = no effect, "-" not known to be present in this portion of the Action Area

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8.0 LIST OF PREPARERS

Karen Charley-Barnes, Senior Project Manager
Ph.D., 2009, Higher Education Administration-Policy Evaluation and Implementation, George Washington University, Washington, D.C.
M.S., 1998, Environmental Science–Policy and Management, Florida A&M University
B.S., 1989, Natural Science and Mathematics, University of Alabama, Birmingham
Years of Experience: 29

Karen Hoksbergen, Biologist, KFS, LLC
M.S., 2004, Biology, Northern Michigan University
B.S., 2001, Biology and Wildlife, University of Wisconsin Stevens Point
Years of Experience: 19

Amy McEniry, Technical Editor, KFS, LLC
B.S., 1988, Biology, University of Alabama in Huntsville
Years of Experience: 32

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Appendix A

Baseline Conditions UES-Consultation Species and Habitats at DoD Test Locations in Kwajalein Atoll

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Baseline Conditions of UES-Consultation Species and Habitats at DoD Test Locations in Kwajalein Atoll

November 2020 Version

Prepared by:

KFS

303 Williams Avenue, Suite 116
Huntsville, AL 35801
Phone 256.713.1616
Fax 256. 713.1617
www.kfs-llc.com

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Acronyms and Abbreviations

μPa	micropascal(s)
ARSTRAT	Army Forces Strategic Command
BA	Biological Assessment
C	Celsius
CBD	Center for Biological Diversity
cm	centimeter(s)
dB	decibel(s)
DEP	Document of Environmental Protection
DoD	Department of Defense
DPS	Distinct Population Segment
DU	depleted uranium
ESA	Endangered Species Act
F	Fahrenheit
FAO	Food and Agriculture Organization of the United Nations
FR	Federal Regulation
ft	feet
ft^3	cubic feet
Hz	hertz
IUCN	International Union for the Conservation of Nature and Natural Resources
kHz	kilohertz
km^2	square kilometer(s)
KMISS	Kwajalein Missile Impact Scoring System
lb	pounds
m	meter(s)
m^3	cubic meter
mi	mile(s)
MIMRA	Marshall Islands Marine Resource Authority
MMIII	Minuteman III
MMPA	Marine Mammal Protection Act
nm	nautical mile(s)
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
PBO	Programmatic Biological Opinion
PIRO	Pacific Islands Regional Office
PTS	permanent threshold shift
RMI	Republic of the Marshall Islands
RTS	Ronald Reagan Ballistic Missile Defense Test Site
SEL	sound exposure level
SPC	The Pacific Community
U.S.	United States
UES	United States Army Kwajalein Atoll Environmental Standards
USAF	United States Air Force
USAG-KA	United States Army Garrison – Kwajalein Atoll
USASMDC	United States Army Space and Missile Defense Command
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey

Baseline Conditions of UES-Consultation Species and Habitats at DoD Test Locations in Kwajalein Atoll

This document was prepared to describe the baseline conditions for species listed as consultation species under Section 3-4 of the United States Army Kwajalein Atoll Environmental Standards (UES) at select United States (U.S.) Department of Defense (DoD) test locations in Kwajalein Atoll. This document is maintained and updated by KFS, LLC to support the evaluation of the effects of various DoD test programs on UES-consultation species and to support consultation with the National Marine Fisheries Service (NMFS) and United States Fish and Wildlife Service (USFWS) where required.

1.0 Locations Considered

The locations considered in this document include select DoD testing locations that are on the U.S. Army Garrison-Kwajalein Atoll (USAG-KA)/Ronald Reagan Ballistic Missile Defense Test Site (RTS) controlled islands and the Mid-Atoll Corridor, as well as all other deep-water sites within the Republic of the Marshall Islands (RMI) at Kwajalein Atoll. Locations considered in this document include:

- Terrestrial areas of Illeginni Islet, focused on the test program impact zone on the western end of the islet (**Figure 1**);
- Nearshore marine areas of Illeginni Islet with focus on areas adjacent to the terrestrial impact zone on Illeginni Islet (**Figure 1**); and
- Three offshore, deep-water test impact zones (**Figure 2**);
  - the Kwajalein Missile Impact Scoring System (KMISS) impact zone,
  - the Southwest Deep Ocean Impact zone southwest of Kwajalein Atoll, and
  - the impact zone in the vicinity (southwest) of Illeginni Islet.

Testing activities at Kwajalein Atoll may include activities outside of these locations; however, the primary stressors related to test program activities are either within or centered on these missile or payload impact sites.

Figure 1. Impact Zone for Testing at Illeginni Islet and Nearshore Survey Areas, Kwajalein Atoll.

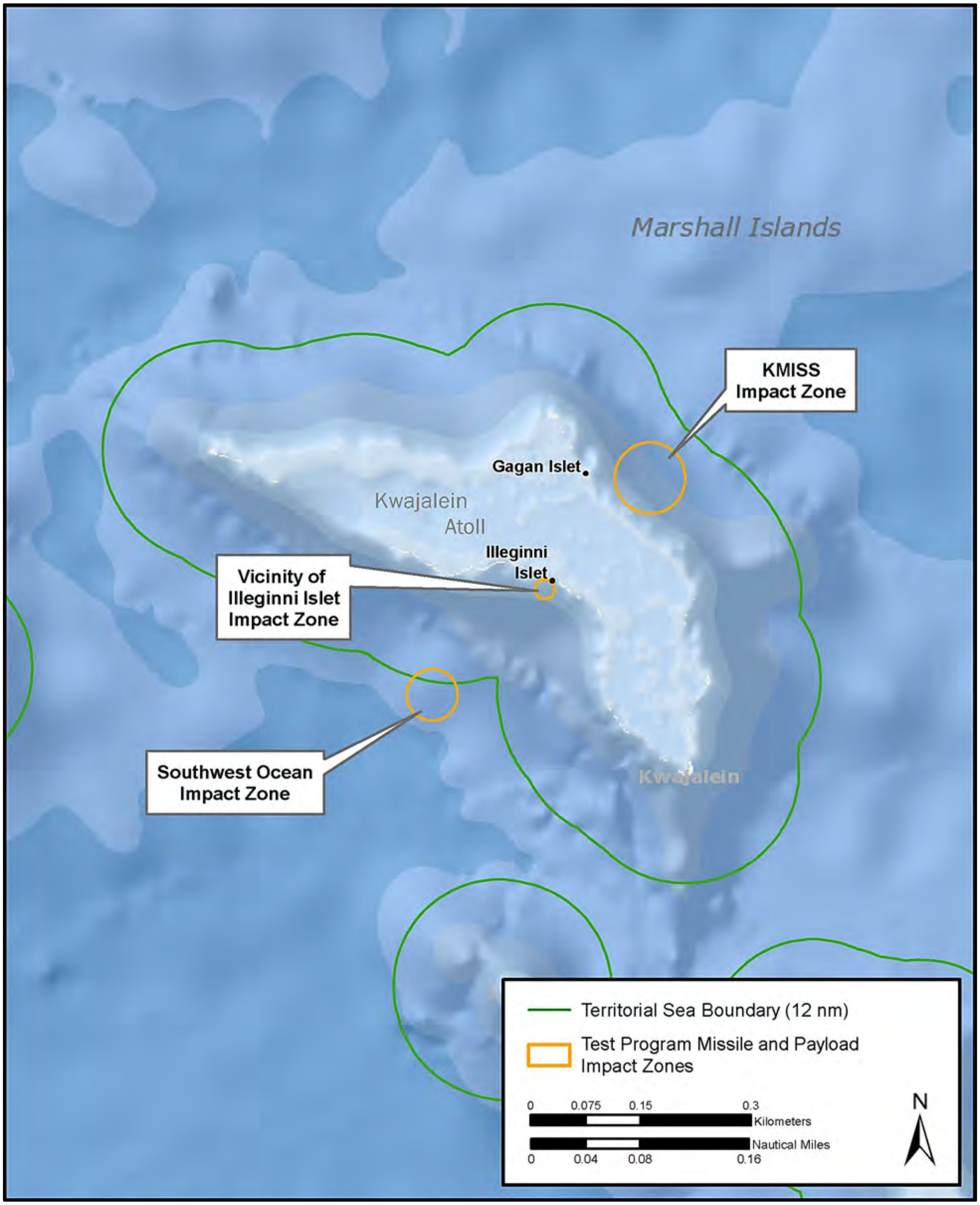

Figure 2. Deep Water Impact Zones for Testing at Kwajalein Atoll.

Illeginni Islet. Illeginni Islet is on the western side of Kwajalein Atoll and has been the site of DoD testing for several decades, including missile and payload impact testing. On Illeginni Islet, the USAG-KA/RTS test impact site is an area approximately 137 meters (m) (450 feet [ft]) by 290 m (950 ft) on the non-forested, northwest end of the islet (**Figure 1**). The only UES-listed species with the potential to use terrestrial habitats at Illeginni Islet are green (*Chelonia mydas*) and hawksbill (*Eretmochelys imbricata*) sea turtles.

Illeginni Islet Nearshore Marine Areas. 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 habitats support a number of reef-associated corals, mollusks, and fish that are listed as consultation species under Section 3-4 of the UES. Human activity and vessel operation resulting from testing activities have the potential to occur in several nearshore marine areas at Illeginni Islet, including Illeginni Harbor. While the presence of UES-species in nearshore areas surrounding all of Illeginni Islet is discussed in this document, the document focuses on UES-consultation species likely to occur in the habitats offshore of the terrestrial impact zone on the western end of Illeginni Islet.

In accordance with requirements specified in the UES, USAG-KA conducts a natural resource baseline survey of USAG-KA controlled islets and associated marine habitats every 2 years to identify and inventory protected or important biological resources (USASMDC/ARSTRAT 2018). USFWS and NMFS personnel have been conducting these biennial biological resource inventories since 1996 to support USAG-KA requirements. The last islet survey occurred in the fall 2018. In addition to biennial resources surveys, NMFS surveyed the surveyed the reef habitats offshore of the test area at Illeginni Islet (**Figure 1**) in 2014 (NMFS-PIRO 2017a). NMFS estimated that these surveys covered all of the reef habitat area potentially affected by payload impact testing on the lagoon side and 99% of the reef area on the ocean side (NMFS-PIRO 2017a and 2017b). These data are still considered the best available information for coral species presence and density offshore of the terrestrial impact zone at Illeginni Islet.

Offshore Test Sites. The KMISS is a system of sensors east of Gagan Islet at Kwajalein Atoll (**Figure 2**). The waters of the KMISS area where payload impacts are conducted are deep-water areas with ocean depth ranging from approximately 2,000 and 10,500 feet (USGS 2007). The waters southwest of Kwajalein Atoll and southwest of Illeginni Islet, often referred to as the "Vicinity of Illeginni Islet" site, are also deep-water, open ocean areas. A wide variety of pelagic and benthic habitats occur in deep-water habitat of Kwajalein Atoll and these habitats support a diversity of marine life. Many special status marine species have the potential to occur in these areas, including cetacean, sea turtle, and fish species protected under the UES (USASMDC/ARSTRAT 2018). Distribution and abundance data in RMI waters is largely lacking for these species. Some species are migratory species which are present in RMI waters seasonally and some others are observed only rarely in the RMI.

2.0 UES-Consultation Species in the Study Area

2.1 Marine Mammals

Sixteen cetacean species protected under the UES have the potential to occur in the waters of Kwajalein Atoll (**Table 1**), four of which are listed under the Endangered Species Act (ESA). All marine mammals discussed in this section are also protected under the Marine Mammal Protection Act (MMPA) (16 USC § 1361 et seq.). The marine mammal species listed in **Table 1** have the potential to occur in the deep-water test sites considered in this document but would not occur in the shallow nearshore waters near the Illeginni Islet impact site. Most of the cetacean species listed in **Table 1** have been observed in the RMI (Miller 2007, Reeves et al. 1999) and are likely to occur in the deep-water DoD test sites such as KMISS and southwest of Illeginni Islet. For other species such as pygmy killer whale (*Feresa attenuata*), Risso's dolphin (*Grampus griseus*), pygmy sperm whale (*Kogia breviceps*), and Blainville's beaked whale (*Mesoplodon densirostris*), potential presence in the waters of Kwajalein Atoll is based on information regarding life history, including feeding patterns, known distribution, and migration patterns, as well as range distribution form the literature sources (NOAA 2020, Reeves et al. 2002, Perrin et al. 2002). The dugong (*Dugong dugong*) may have occurred historically at Kwajalein Atoll according to an appendix of the UES. However, this species has not been reported in Kwajalein Atoll for many decades.

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

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

Measurements for sound pressure levels in air are generally referenced to (re) 20 micropascals (μPa), and underwater sound levels are standardized to 1 μPa at 1 m (3.3 ft). In the waters of Kwajalein Atoll, some of the loudest underwater sounds generated are most likely to originate from storms, ships, and some marine mammals. Thunder can have source levels of up to 260 decibels (dB) re 1 μPa. A passing supertanker can generate up to 190 dB re 1 μPa of low frequency sound.

Table 1. Marine Mammal Species Requiring Consultation under the UES that have the Potential to Occur in Kwajalein Atoll Waters.

Scientific Name	Common Name	UES Consultation Species Listing Status(1)		
		ESA	MMPA	RMI Statute
Balaenoptera musculus	Blue whale	E	Migratory	1
B. physalus	Fin whale	E	Migratory	
Delphinus delphis	Short-beaked common dolphin			2
Feresa attenuata	Pygmy killer whale		Resident	
Globicephala macrorhynchus	Short-finned pilot whale		Migratory	
Grampus griseus	Risso's dolphin		Resident	
Kogia breviceps	Pygmy sperm whale		Migratory	
Megaptera novaeangliae	Humpback whale (Western North Pacific DPS)(2)	E(2)	Migratory	
Mesoplodon densirostris	Blainville's beaked whale		Migratory	
Orcinus orca	Killer whale		Resident	
Peponocephala electra	Melon-headed whale		Resident	
Physeter macrocephalus	Sperm whale	E	Resident	1
Stenella attenuata	Pantropical spotted dolphin			2
S. coeruleoalba	Striped dolphin			2
S. longirostris	Spinner dolphin		Resident	2
Tursiops truncatus	Bottlenose dolphin		Resident	

Sources: USASMDC/ARSTRAT 2018, NOAA 2020, U.S. Navy 2019

Notes:

(1) UES Consultation Species Listing Status based on Appendix 3-4A of the UES (USASMDC/ARSTRAT 2018).
RMI Statutes: 1 = Endangered Species Act 1975, Title 8 MIRC Chapter 3; 2 = Marine Mammal Protection Act 1990, Title 33 MIRC Chapter 2

(2) The DPSs of humpback whales likely in Kwajalein Atoll Waters (Oceania DPS) are not listed under the ESA; however, there is some uncertainty about which DPS whales in the area belong to.

Abbreviations: DPS = Distinct Population Segment, E = ESA Endangered, ESA = U.S. Endangered Species Act, MMPA = Marine Mammal Protection Act, UES: United States Army Kwajalein Atoll Environmental Standards (USASMDC/ARSTRAT 2018 Section 3-4.5.1).

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

2.1.1 Blue Whale (Balaenoptera musculus)

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

Distribution. The blue whale inhabits all oceans of the world and while they are sometimes found in coastal waters, they are predominantly found offshore (Sears 2002). Blue whales in the North Pacific are divided into two management stocks; the eastern Pacific management stock and the central Pacific management stock. The central Pacific management stock migrates seasonally between summer feeding grounds in the north-central Pacific and wintering areas in lower latitudes of the western and central Pacific including Hawai`i (Carretta et al. 2020). Blue whales are most often observed alone or with one to two individuals but can be found in groups of 50 or more in very productive areas (Sears 2002). Calving occurs in winter (Sears 2002) and likely in tropical and subtropical waters (Jefferson et al. 2008).

Threats. Widespread whaling over the last century is believed to have decreased the population to approximately 1% of its pre-whaling population size (Sirovic et al. 2004). Blue whales are susceptible to the same potential threats that are generally applicable to all cetacean species known to occur in the waters of Kwajalein Atoll. There are no known threats at Kwajalein Atoll that are specific to only blue whales; however, due to the small population size, vessel strikes, fisheries interactions, ocean noise, habitat degradation, pollution, and climate change (NOAA 2020) are all significant threats for this species.

Populations at Kwajalein Atoll. The blue whale range includes the deep ocean waters of the RMI. Blue whales have been sighted in areas surrounding the RMI (Reeves et al. 1999, Miller 2007). Blue whales have been recorded in Tonga and may breed in these areas, migrating from feeding waters off New Zealand (Balcazar et al. 2015). There is no available information on the abundance of blue whales in the RMI.

2.1.2 Fin Whale (Balaenoptera physalus)

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

Distribution. The fin whale is found in all the world's oceans (Jefferson et al. 2008). This whale inhabits deep, offshore waters in temperate to polar latitudes, and less often in tropical latitudes (NOAA 2020, Reeves et al. 2002). Fin whales are also often seen close to shore after periodic patterns of upwelling and the resultant increase in the density of krill upon which they feed (Azzellino et al. 2008). Pacific fin whale population structure is not well known. There are three recognized stocks of fin whales in the north Pacific: the Hawai`i stock, the California/Oregon/ Washington stock, and the Alaska stock (Carretta et al. 2020).

Threats. Fin whales are susceptible to the same potential threats that are generally applicable to all cetacean species known to occur in the waters of Kwajalein Atoll. Major threats for this species include vessel strikes, entanglement, and ocean noise which can interrupt normal behavior and diving (NOAA 2020).

Populations at Kwajalein Atoll. Little or no information is available regarding the population of fin whales in the RMI. These whales do occur in the central and western Pacific Ocean, including in the RMI (Reeves et al. 1999, Miller 2007).

2.1.3 Short-beaked Common Dolphin (Delphinus delphis)

Species Description. These small, 2 m (6 ft) long dolphins are usually found in large social groups of hundreds of individuals composed of smaller (20–30 dolphins) subunits (Perrin 2002a, NOAA 2020). Short-beaked common dolphins are often active at the surface and are capable of diving to at least 200 m (650 ft) to feed on fish (NOAA 2020). Common dolphins are often found near underwater features such as ridges, continental shelves, and seamounts with abundant prey (NOAA 2020). In the eastern tropical Pacific, calving takes place all year but may be more seasonal in populations at higher latitudes (NOAA 2020). Functional hearing for the short-beaked common dolphin is estimated to occur between approximately 150 Hz and 160 kHz, placing them among the group of cetaceans that can hear mid-frequency sounds (Southall et al. 2007).

Distribution. This relatively common species prefers warm tropical to cool tropical waters from about 60°N to 50°S in habitats with upwelling (Perrin 2002a). Although short-beaked common dolphins primarily occur in deep waters beyond the edge of the continental shelf, they do come into continental shelf waters in some season (Jefferson et al. 2008) in areas where waters are 200–2,000 m (650–6,500 ft) deep (NOAA 2020). Cañadas and Hammond (2008) observed that groups of short-beaked common dolphins with calves and groups that were feeding preferred more coastal waters. The short-beaked common dolphin is not considered to be a truly migratory species, although seasonal shifts which vary with ocean conditions have been documented in the eastern Pacific (Perrin 2002a). In the north Pacific, short-beaked common dolphins are found primarily off the coast of North America, north of the Hawaiian Islands, and near Japan south to New Zealand (Perrin 2002a, IUCN 2018).

Threats. Short-beaked common dolphins are susceptible to the same potential threats that are generally applicable to all cetacean species known to occur in the waters of Kwajalein Atoll.

Populations at Kwajalein Atoll. The short-beaked common dolphin has been documented in the central and western Pacific Ocean in the Cook Islands, Fiji, and in the deep ocean areas of the RMI (Reeves et al. 1999, Miller 2007). This species has the potential to occur in deep ocean areas of Kwajalein Atoll and near Illeginni Islet.

2.1.4 Pygmy Killer Whale (Feresa attenuata)

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

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

Threats. Pygmy killer whales are susceptible to the same potential threats that are generally applicable to all cetacean species known to occur in the waters of Kwajalein Atoll.

Populations at Kwajalein Atoll. There are no documented pygmy killer whale occurrences in the deep ocean areas of the RMI (Reeves et al. 1999, Miller 2007). In the western Pacific Ocean, the only documented occurrences are in French Polynesia.

2.1.5 Short-finned Pilot Whale (Globicephala macrorhynchus)

Species Description. The short-finned pilot whale is a 1.9 to 7.2 m (6.2 to 23.6 ft) long delphinid (Bernard and Reilly 1999). These whales occur in groups of 5 to 50 animals (Bernard and Reilly 1999) and feed primarily on squid, octopus, and fish in waters 305 m (1,000 ft) deep or more (NOAA 2020). Short-finned pilot whales near Japan had a peak breeding season in

April and May and birth of calves in July and August; however, a small number of births were recorded year-round (Bernard and Reilly 1999). The region of best hearing for pilot whales is believed to be between 11.2 and 50 kHz with relatively poor high frequency hearing, compared with other odontocete species and auditory thresholds as low as 50 dB re 1 µPa (Pacini et al. 2010). Pilot whales are in the mid-frequency cetaceans functional hearing group (Southall et al. 2007).

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

Threats. Short-finned pilot whales are susceptible to the same potential threats that are generally applicable to all cetacean species known to occur in the waters of Kwajalein Atoll. Current predominant threats to short-finned pilot whales include entanglement in fishing gear, hunting, and vessels strikes (NOAA 2020).

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

2.1.6 Risso's Dolphin (Grampus griseus)

Species Description. Risso's dolphins are blunt-headed delphinids up to 4.1 m (13.5 ft) long (Kruse et al. 1999). These gregarious dolphins may form groups of several hundred individuals comprised of smaller subgroups (Kruse et al. 1999). Risso's dolphins are believed to feed primarily on cephalopods at night (Kruse et al. 1999). During typical surfacing sequences, these dolphins surface every 7 seconds; however, individuals may remain submerged on dives as long as 30 minutes (Kruse et al. 1999). Little is known about reproduction of Risso's dolphins, but there may be a peak in calving during the winter months (Baird 2002). Nachtigall et al. (1995) measured hearing in an adult Risso's dolphin in a natural setting and found that adult hearing ranged from 4 to 64 kHz with thresholds as low as 63.7 dB at 8 kHz (Kruse et al. 1999). Risso's dolphins are among the group of cetaceans that are categorized as mid-frequency cetaceans (Southall et al. 2007).

Distribution. Risso's dolphins occur in temperate, subtropical, and tropical waters throughout the world (NOAA 2020) from between 60°N and 60°S (Kruse et al. 1999). These dolphins are most commonly found seaward of the continental slope in waters that are generally greater than

1,000 m (3,300 ft) (NOAA 2020) and are known to frequent seamounts and other areas with steep bottom topography (Kruse et al. 1999). These dolphins are commonly found in waters between 15 and 20 degrees Celsius (°C, or 59 and 68 degrees Fahrenheit [°F]) and are not known to occur in waters below 10 °C (50 °F) (Baird 2002). Risso's dolphins are known to have seasonal shifts in abundance in some portions of their range which may be due to shifting prey abundance, but in some portions of their range there is evidence that abundance remains relatively constant throughout the year (Kruse et al. 1999). Populations of this species occur near Japan, in the eastern tropical Pacific, the U.S. west coast, and around the Hawaiian Islands (Carretta et al. 2020).

Threats. Risso's dolphins are susceptible to the same potential threats that are generally applicable to all cetacean species known to occur in the waters of Kwajalein Atoll. Some of the major threats to these dolphins include entanglement in fishing gear, hunting, ocean noise and contaminants that bioaccumulate in their prey (NOAA 2020).

Populations at Kwajalein Atoll. There are documented occurrences of Risso's dolphins in the central and western Pacific Ocean in the Cook Islands, French Polynesia, and Guam (Reeves et al. 1999, Miller 2007). However, based on the distribution of this species in the Central Pacific, this species has the potential to occur at Kwajalein Atoll.

2.1.7 Pygmy Sperm Whale (Kogia breviceps)

Species Description. Pygmy sperm whales reach lengths of 3.8 m (12.5 ft) and weigh up to 450 kilograms (kg; 990 lb) (McAlpine 2002). Pygmy sperm whales are considered to be a deep-diving species, based on stomach contents and long dive durations (McAlpine 2002). Pygmy sperm whales are a type of toothed whale, which feeds on mid- to deep-water cephalopods and, less often, on deep-sea fish and crustaceans (Beatson 2007, West et al. 2009). Pygmy sperm whales may occur individually or in small groups of up to about six animals (Caldwell and Caldwell 1989). An auditory brainstem response study completed on a stranded pygmy sperm whale indicated best hearing sensitivity between 90 and 150 kHz (Ridgway and Carder 2001). Functional hearing is estimated to occur between approximately 200 Hz and 180 kHz, placing them among the group of cetaceans that can hear high-frequency sounds (Southall et al. 2007).

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

Threats. Pygmy sperm whales are susceptible to the same potential threats that are generally applicable to all cetacean species known to occur in the waters of Kwajalein Atoll. These whales may be especially susceptible to threats such as entanglement, hunting, vessel strike, ingestion of marine debris, and ocean noise (NOAA 2020).

Populations at Kwajalein Atoll. *Kogia* sp. whales have been documented in French Polynesia, Guam, the Northern Mariana Islands, and Samoa, but there are no documented occurrences or abundance estimates in the deep ocean areas of the RMI (Reeves et al. 1999, Miller 2007). Based on the distribution of pygmy sperm whales in the Central Pacific, this species has the potential to occur at Kwajalein Atoll.

2.1.8 Humpback Whale (Megaptera novaeangliae)

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

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

Distribution. The humpback whale is found throughout the world in all ocean basins (Carretta et al. 2020). These whales are typically found during the summer on high latitude feeding grounds and during the winter in the tropics and subtropics around islands, over shallow banks, and along continental coasts, where calving occurs (Clapham 2002). Most humpback whale sightings are in nearshore and continental shelf waters; however, humpback whales frequently travel through deep oceanic waters during migration (Calambokidis et al. 2001). On breeding grounds, females with calves occur in significantly shallower waters than other groups of whales, and breeding adults use deeper more offshore waters (Ersts and Rosenbaum 2003, Smultea 1994). Whales that winter in Hawai`i are most likely to migrate to feeding grounds in southeastern Alaska (Calambokidis et al. 2001).

Threats. Humpback whales are susceptible to the same potential threats that are generally applicable to all cetacean species known to occur in the waters of Kwajalein Atoll. As an endangered species, any threats to humpback whale are particularly significant including threats from vessel strike, entanglement in fishing gear, vessel-based harassment, habitat modification, and ocean noise (NOAA 2020).

Populations at Kwajalein Atoll. There are historical records of humpback whale sightings in the RMI (Reeves et al. 1999, Miller 2007). There is no available information on the abundance of humpback whales in the deep ocean areas of the RMI. Oceania humpback whale populations are estimated to number 3,827 (coefficient of variation=0.12) individuals; however, the population appears to be subdivided with relatively little known about the movements and feeding areas for these whales (Bettridge et al. 2015).

2.1.9 Blainville's Beaked Whale (Mesoplodon densirostris)

Species Description. Blainville's beaked whales reach 4.7 m (15 ft) long (Pitman 2002) and weigh 816 to 1,043 kg (1,800 to 2,300 lb) (NOAA 2020). As in other beaked whale species, Blainville's beaked whales appear to feed on squid and some fish in deep waters (Pitman 2002). Little is known about the movements or behavior or beaked whales. These whales are known to dive from 20 to over 45 minutes at a time (Pitman 2002). An audiogram of a Blainville's beaked whale revealed the range of best hearing was 40 to 50 kHz for this species with thresholds as low at 48.9 dB (Pacini et al. 2011). Beaked whales are part of the mid-frequency cetaceans functional hearing group with an estimated auditory bandwidth of 150 Hz to 160 kHz (Southall et al. 2007).

Distribution. Blainville's beaked whales are one of the most widely distributed of the distinctive toothed whales in the Mesoplodon genus and are found throughout the world in tropical, sub-tropical, and warm temperate waters (MacLeod et al. 2006). These whales are known to occur along the California coast, Hawai`i, and in the Eastern Tropical Pacific and some research indicates they are found mostly offshore in deeper waters (MacLeod and Mitchell 2006). In other studies, these whales have been found to prefer water depths of 200 to 1,000 m (656 to 3,280 ft) (IUCN 2018). In a 2013 habitat use study around the main Hawaiian Islands, Blainville's beaked whales had a bimodal pattern of sighting by water depth with peak encounter rates between 500 and 1,500 m (1,640-4,921 ft) deep and between 3,500 and 4,000 m (11,483-13,123 ft) deep (Baird et al. 2013). It is unknown whether this species makes specific migrations.

Threats. Blainville's beaked whales are susceptible to the same potential threats that are generally applicable to all cetacean species known to occur in the waters of Kwajalein Atoll.

Populations at Kwajalein Atoll. There are documented occurrences of Blainville's beaked whales in a number of island chains in the central and western Pacific, but there are no documented occurrences or abundance estimates in the RMI (Reeves et al. 1999, Miller 2007). Based on their occurrence in the central Pacific and the best information on their range, Blainville's beaked whales have the potential to occur in deeper waters of Kwajalein Atoll.

2.1.10 Killer Whale (Orcinus orca)

Species Description. Killer whales are considered depleted under the MMPA and potential populations in the waters of Kwajalein Atoll are not listed under the ESA. These highly social animals occur most commonly in groups from 2 to 15 animals (NOAA 2020). These whales feed on a variety of prey including marine mammals, fish, cephalopods, sea turtles, and sea birds (Ford 2009). Killer whales forage either individually, in small groups, or cooperatively depending on the whale population and prey type (Ford 2009). Killer whales may calve in any month of the year, but most births are in October–March (Ford 2009). Recent behavioral audiograms of killer whales indicated hearing between 600 Hz and 114 kHz with best hearing at 34 kHz with a 49 dB re 1 µPa threshold (Branstetter et al. 2017). Another study using behavioral and auditory evoked potential audiograms of two captive killer whales indicate that they can hear sounds ranging from 1 to 120 kHz (best hearing ranging from 18 to 42 kHz), with most sensitivity at 20 kHz and a detection threshold of 36 dB re 1 µPa (Szymanski et al. 1999). The full range of functional hearing is estimated to occur between approximately 150 Hz and 160 kHz, placing them among the group of cetaceans that can hear mid-frequency sounds (Southall et al. 2007).

Distribution. Killer whales are found in all oceans of the world and are most common in coastal temperate waters (Ford 2009). Eight killer whale stocks are recognized in the Pacific U.S. exclusive economic zone (Carretta et al. 2020). Although considered one species, killer whales are broken down into different “ecotypes” that are distinguished by distinct social and foraging behaviors and other ecological traits (Ford 2009). In the North Pacific, these distinct forms are known as resident, transient, and offshore ecotypes (NOAA 2020).

Killer whales are found in all marine habitats, from the coastal zone (including most bays and inshore channels) to deep oceanic basins and from equatorial regions to the polar pack ice zones of both hemispheres (Dahlheim and Heyning 1999). Although killer whales are also found in tropical waters and the open ocean, they are most abundant in coastal habitats at high latitudes (Dahlheim and Heyning 1999). In most areas of their range, killer whales do not show movement patterns that would be classified as traditional migrations. However, some populations exhibit seasonal shifts in density, likely in response to prey availability (Ford 2009).

Threats. Killer whales are susceptible to the same potential threats that are generally applicable to all cetacean species known to occur in the waters of Kwajalein Atoll. Major threats for this species include food depletion from overfishing and habitat loss, contaminants, oil spills, disturbance from vessels, and ocean noise (NOAA 2020).

Populations at Kwajalein Atoll. There have been documented occurrences of Killer whales in the western Pacific, as well as in the RMI (Reeves et al. 1999, Miller 2007). Three killer whales were sighted 4.73 km (2.94 mi) off of the coast of South Pass in April of 2007 (USAF 2007). There is no available information on the abundance of killer whales in the RMI.

2.1.11 Melon-headed Whale (Peponocephala electra)

Species Description. Melon-headed whales reach lengths of 2.7 m (8.9 ft) (Perryman 2002). These whales are often found in large groups, sometimes in mixed aggregations with Fraser’s dolphins or spinner dolphins (Perryman 2002). Most of the fish and squid families eaten by this toothed whale species consist of mid-water forms found in waters up to 1,500 m (4,920 ft) deep, suggesting that feeding takes place deep in the water column (Jefferson and Barros 1997). Melon-headed whales feed primarily on squid but have also been known to eat small fish and shrimp (Perryman 2002). Whether calving is significantly seasonal is unclear, but some evidence suggests a peak in July and August (Jefferson and Barros 1997). While no empirical data on hearing ability for this species are available, functional hearing is estimated to occur between approximately 150 Hz and 160 kHz, placing them among the group of cetaceans that can hear mid-frequency sounds (Southall et al. 2007).

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

Threats. Melon-headed whales are susceptible to the same potential threats that are generally applicable to all cetacean species known to occur in the waters of Kwajalein Atoll. Major threats to melon-headed whales include entanglement in fishing gear, pollution, and ocean noise (NOAA 2020).

Populations at Kwajalein Atoll. There have been documented occurrences of melon-headed whales in the central and western Pacific and in the deep ocean areas of the RMI (Reeves et al. 1999, Miller 2007). There was a sighting of five whales 4.8 km (3 mi) off the coast of Kwajalein on 23 October 2005 (USAF 2007). There are no abundance estimates available for the RMI.

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

2.1.12 Sperm Whale (Physeter macrocephalus)

Species Description. Sperm whales have been endangered since 1970 under the precursor to the ESA and are listed as depleted under the MMPA. Sperm whales are largest of the toothed whales, reaching lengths of 16 m (52 ft) (Whitehead 2002). Females inhabit deeper waters (greater than 1,000 m [3,280 ft]) at latitudes below 40° and are highly social (Whitehead 2002). Female sperm whales spend most of their lives in family units of about 12 females with communal defense and care of young (Whitehead 2002). Male sperm whales may be found at higher latitudes but are more likely to be observed in productive waters such as those along the edges of continental shelves (Whitehead 2002). Sperm whales are deep divers, feeding primarily on squid and other cephalopods as well as on bottom-dwelling fish and invertebrates (Whitehead 2002, Davis et al. 2007). These large whales spend most of their time in deep waters where their prey are found (NOAA 2020).

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

Distribution. Sperm whales are divided into three stocks in the Pacific U.S. exclusive economic zone: (1) the Hawaiian stock, (2) the California, Oregon, and Washington stock, and (3) the Alaskan stock. Sperm whales show a strong preference for deep waters (Rice 1989, Whitehead 2003). Adult females are generally found far from land at latitudes less than 40° and in waters 1,000 m (3,280 ft) or deeper (Whitehead 2002). Although adult males are more likely to be observed in deeper, productive waters (Whitehead 2002), in some areas adult males frequent waters with bottom depths less than 100 m (330 ft) and as shallow as 40 m (130 ft) (Romero et al. 2001). In a habitat use study around the main Hawaiian Islands, sperm whales were observed most frequently in waters greater than 3,000 m (9,842 ft) deep (Baird et al. 2013). Female sperm whales and young are typically found far from land (Whitehead 2002). Typically, sperm whale concentrations occur in areas with high biomass of deep-water prey which are generally near drop-offs such as the edges of continental shelves (Whitehead 2002). Sperm whales are somewhat migratory depending on their location, gender, and prey abundance (NOAA 2020). General shifts occur during the summer for feeding and breeding, while in some tropical areas, sperm whales appear to be largely resident (Rice 1989, Whitehead 2003, Whitehead et al. 2008).

Threats. Sperm whales are susceptible to the same potential threats that are generally applicable to all cetacean species known to occur in the waters of Kwajalein Atoll. Major threats to sperm whales include vessel strike, entanglement in fishing gear, ocean noise, ingestion of marine debris, contaminants, and habitat and food availability changes resulting from climate change (NOAA 2020).

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

Sperm whales have been documented in many of the island chains in the central and western Pacific, including the RMI (Reeves et al. 1999, Miller 2007). An acoustic study performed off of the coast of Kwajalein Atoll in 2007 reported almost continuous detection of sperm whale sounds in the 26, 44, and 46 days of the study. This study concluded that sperm whales are highly active in the area during March, May, and September (Nosal 2011). In April 2009, four individuals with calves were reported in the open ocean area surrounding Kwajalein Atoll (9° 00.27' N, 167° 01.30' W), 4.8 km (3 mi) off Legan Islet. These whales were observed breaching, lobtailing, diving, and resting (USAKA 2009). There is no available information on the abundance of sperm whales in the RMI.

2.1.13 Pantropical Spotted Dolphin (Stenella attenuata)

Species Description. Adult pantropical spotted dolphins are 166 to 2.57 m (5.45 to 8.43 ft) long and weigh up to 119 kg (262 lb) (Perrin 2002b). Pantropical spotted dolphins prey on near-surface fish, squid, and crustaceans and on some benthic species (Perrin 2002b). Results from various tracking and food habit studies suggest that pantropical spotted dolphins in the eastern tropical Pacific and off Hawai`i feed primarily at night on surface and mid-water species (Baird et al. 2001, Robertson and Chivers 1997). Pantropical spotted dolphins are known to breed year-round and occur in groups of several hundred to a thousand animals (NOAA 2020).

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

Distribution. The pantropical spotted dolphin is distributed worldwide in offshore tropical and subtropical waters between about 40°N and 40°S latitudes (Perrin 2002b). It is found mostly in deeper offshore waters but does approach the coast in some areas (Perrin 2001). In the eastern tropical Pacific, pantropical spotted dolphins are most abundant in waters with a sharp thermocline at depths of 50 m (164 ft) or less (Perrin 2002b). Based on known habitat preferences, occurrence is expected in waters 90 to 300 m (300 to 1,000 ft) deep during the day and possibly in deeper waters at night when foraging for prey (NOAA 2020). Although pantropical spotted dolphins do not migrate, extensive movements are known in the eastern tropical Pacific (Scott and Chivers 2009).

Threats. Pantropical spotted dolphins are susceptible to the same potential threats that are generally applicable to all cetacean species known to occur in the waters of Kwajalein Atoll. Major threats for this species include entanglement in fishing gear, interactions with people, and hunting (NOAA 2020).

Populations at Kwajalein Atoll. Pantropical spotted dolphins are frequently sighed in pelagic waters. There are documented occurrences of the pantropical spotted dolphin in the central and western Pacific Ocean in American Samoa, Cook Islands, Fiji, French Polynesia, and Kiribati and in the deep ocean areas of the RMI (Reeves et al. 1999, Miller 2007).

2.1.14 Striped Dolphin (Stenella coeruleoalba)

Species Description. Striped dolphins are small dolphins that reach lengths of 2.4 m (7.9 ft) in the western Pacific and are often observed in schools of 10 to several hundred individuals (Archer 2002). Striped dolphins often feed on fish and squid in open sea or sea bottom zones beyond the continental shelf where they dive from 200 to 700 m (656 to 2,297 ft) for prey (Archer 2002). Striped dolphins give birth to a single calf during summer or autumn (NOAA 2020). Kastelein et al. (2003), using standard psychoacoustic techniques, measured a striped dolphin's range of most sensitive hearing to be 29 to 123 kHz, with maximum sensitivity occurring at 64 kHz with a signal strength of 42 dB re 1 µPa. Striped dolphins are in the mid-frequency functional hearing group for cetaceans which are estimated to have a full range of functional hearing between 150 Hz and 160 kHz (Southall et al. 2007).

Distribution. Striped dolphins are found primarily in warm equatorial and tropical waters but appear to prefer waters with more variable conditions with upwelling and large seasonal changes in temperature structure (Au and Perryman 1985). This abundant and widespread species is generally restricted to pelagic regions and are seen close to shore only where deep water approaches the coast. In some areas (e.g., the eastern tropical Pacific), they are mostly associated with convergence zones and regions of upwelling (Au and Perryman 1985, Reilly 1990).

Threats. Striped dolphins are susceptible to the same potential threats that are generally applicable to all cetacean species known to occur in the waters of Kwajalein Atoll. Major threats for striped dolphins include entanglement in fishing gear, disease (specifically morbillivirus), and hunting (NOAA 2020).

Populations at Kwajalein Atoll. These dolphins are abundant and widespread in oceanic regions. In a habitat use study around the main Hawaiian Islands, striped dolphins were among the most commonly observed cetaceans and were found at their highest rates in very deep water (> 3,000 m [9,843 ft]) (Baird et al 2013). The range of the striped dolphin includes the deep ocean waters of the RMI. In the central and western Pacific Ocean, there are documented occurrences in Micronesia and the RMI (Crawford 1993, Reeves et al. 1999, Miller 2007).

2.1.15 Spinner Dolphin (Stenella longirostris)

Species Description. Adult spinner dolphins range in length from 1.29 to 2.35 m (4.23 to 7.71 ft) (Perrin and Gilpatrick 1994). Spinner dolphins feed primarily on small mid-water fishes, squid, and shrimp, and they dive to at least 200 to 300 m (655 to 985 ft) (Perrin and Gilpatrick 1994). Spinner dolphins have variable school size and are commonly found in schools with pantropical spotted dolphins (Perrin and Gilpatrick 1994). Mating and calving occur throughout the year but may be more seasonal in some regions (Perrin and Gilpatrick 1994). Dolphins in the genus *Stenella* are considered part of the mid-frequency cetaceans function hearing group which has an estimated auditory bandwidth of 150 Hz to 160 kHz (Southall et al. 2007).

Distribution. Spinner dolphins occur throughout tropical and subtropical waters in both hemispheres (Perrin and Gilpatrick 1994). Spinner dolphins occur in large numbers in oceanic habitats but some populations in the eastern Pacific and in tropical waters occur in coastal habitats as well (Perrin and Gilpatrick 1994). In most areas, including the eastern tropical Pacific, spinner dolphins are found primarily in deep ocean waters (Perrin and Gilpatrick 1994). In the central and western Pacific, spinner dolphins are island-associated and expected to occur in shallow water resting areas (about 50 m [164 ft] deep or less) throughout the middle of the day, moving into deep waters offshore during the night to feed (Carretta et al. 2020). Island-associated stocks have an offshore boundary of 18.5 km (10 nm) from shore based on observations that no dolphins have been seen farther than 18.5 km (10 nm) from shore (Carretta et al. 2020). Spinner dolphins are reported to have strong seasonal shifts in habitats with year-to-year variation in habitat use (Perrin and Gilpatrick 1994).

Threats. Spinner dolphins are susceptible to the same potential threats that are generally applicable to all cetacean species known to occur in the waters of Kwajalein Atoll. Major threats for spinner dolphins include entanglement in fishing gear, illegal feeding and harassment, habitat degradation, ocean noise, disease, and vessel strike (NOAA 2020).

Populations at Kwajalein Atoll. Spinner dolphins are known to occur in the central and western Pacific Ocean in American Samoa, Cook Islands, Micronesia, Fiji, French Polynesia, Guam, Kiribati, New Caledonia, Niue, CNMI, Papua New Guinea, Samoa, Solomon Islands, Tonga, Tuvalu, and Vanuatu (Miller 2007). There have been multiple surface sightings of spinner dolphins recorded at Kwajalein Atoll and on 27 July 2006, a large group of spinner dolphins was sighted near the helipad on Illeginni Islet (USAF 2007). Because of the number of sightings of spinner dolphins in the area, as well as in the deep ocean waters of Kwajalein Atoll, it is likely that they are relatively common around Illeginni Islet.

2.1.16 Bottlenose Dolphin (Tursiops truncatus)

Species Description. Bottlenose dolphins are commonly found in groups of 2-15 individuals but larger groups of up to 1,000 have been recorded (Wells and Scott 2002). Group size and feeding habits may differ between coastal and pelagic populations with smaller group sizes in inshore populations (Wells and Scott 2002). Bottlenose dolphins feed primarily on bottom dwelling fish and squid, but some surface dwelling or pelagic fish are also consumed (Wells and

Scott 2002). Bottlenose dolphins have been known to give birth in all seasons; however, calving occurs primarily in winter (Wells and Scott 2002).

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

Distribution. The bottlenose dolphin has a worldwide distribution ranging from latitudes of 45°N to 45°S (Wells and Scott 2002). Bottlenose dolphins are found both in coastal and offshore waters with surface temperatures between 10 and 32°C (Wells and Scott 2002). Some populations of bottlenose dolphin appear to be migratory, others have year-round home ranges, and some a combination of long-range movements and local residency (Wells and Scott 2002). In the Hawaiian Islands stock complex, over 99% of the bottlenose dolphins belonging to the insular populations were documented in waters of 1,000 m (3,280 ft) or less (Carretta et al. 2020). In a habitat use study around the main Hawaiian Islands, Baird et al. (2013) recorded bottlenose dolphins throughout the year with most observations in waters less than 500 m (1,640 ft) deep. A Hawai`i pelagic stock is recognized, although little is known about their distribution.

Threats. Bottlenose dolphins are susceptible to the same potential threats that are generally applicable to all cetacean species known to occur in the waters of Kwajalein Atoll. Major threats for bottlenose dolphins include entanglement in fishing gear, habitat destruction and degradation, biotoxins linked to algal blooms, and illegal feeding and harassment (NOAA 2020).

Populations at Kwajalein Atoll. There are coastal stocks of bottlenose dolphins around many central Pacific islands including the Hawaiian Islands (Carretta et al. 2020). Little is known about the density and distribution of the pelagic stock of this species in the central and eastern Pacific.

There are documented occurrences of the bottlenose dolphin in the central and western Pacific in American Samoa, Micronesia, Fiji, French Polynesia, and Kiribati and in the deep ocean areas of the RMI (Reeves et al. 1999, Miller 2007).

2.2 Reptiles

Two sea turtle species have the potential to be present at Kwajalein Atoll: green (*Chelonia mydas*) and hawksbill (*Eretmochelys imbricata*) turtles (**Table 2**). Both of these species are listed under the ESA and are UES consultation species.

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

Table 2. Reptile Species Requiring Consultation under the UES that have the Potential to Occur in Kwajalein Atoll Waters and on Illeginni Islet.

Scientific Name	Common Name	UES Consultation Species Listing Status[1]	
		ESA	RMI Statute
Chelonia mydas	Green turtle (Central West Pacific DPS)	E	1, 3
Eretmochelys imbricata	Hawksbill turtle	E	3

Sources: USASMDC/ARSTRAT 2018, U.S. Navy 2019

Note:

(1) UES Consultation Species Listing Status based on Appendix 3-4A of the UES (USASMDC/ARSTRAT 2018).
RMI Statutes: 1 = Endangered Species Act 1975, Title 8 MIRC Chapter 3; 3 = Fisheries Act 1997, Title 51 MIRC Chapter 2

Abbreviations: DPS = Distinct Population Segment, E = ESA Endangered, ESA = U.S. Endangered Species Act, UES: United States Army Kwajalein Atoll Environmental Standards (USASMDC/ARSTRAT 2018 Section 3-4.5.1).

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

Global climate change, with predictions of increased ocean and air temperatures and sea level rise, may also negatively impact turtles in all life stages, from egg to adult (Griffin et al. 2007, Poloczanska et al. 2009). Effects include embryo death caused by high nest temperatures, skewed sex ratios due to increased sand temperature, decreased growth rates, loss of nesting habitat to beach erosion, coastal habitat degradation (e.g., increased water temperature and disease), as well as, alteration of the marine food web, which can decrease the amount of prey species (Poloczanska et al 2009). A recent study of green sea turtles foraging in the Great

Barrier Reef found that warmer beaches are producing primarily female turtles (87–99% of turtles) (Jensen et al. 2018). Bjorndal et al. (2017) found declines in the growth rate of green turtles after 1999 and cite previous studies that revealed similar declines in hawksbill and loggerhead turtles starting in 1997. Ecological shifts due to warming waters, changing weather patterns, and anthropogenic activities may be among the stressors contributing to decreased growth rates in sea turtles (Bjorndal et al. 2017).

In the RMI, sea turtles are an important part of Marshallese culture. They are featured in many myths, legends, and traditions, where they are revered as sacred animals. Eating turtle meat and eggs on special occasions remains a prominent part of the culture. Presently, despite national and international protection as endangered species, marine turtles remain prestigious and a highly desired source of food in the RMI (Kabua and Edwards 2010). Turtles have long been a food source in the RMI, though the level of exploitation is unknown. Direct harvest of eggs and nesting adult females from beaches, as well as direct hunting of turtles in foraging areas, continues in many areas. Anecdotal information from RMI residents suggests a decline in the green turtle population, possibly of up to 50% in the last 10 years (McCoy 2004). The harvest of sea turtles in the RMI is regulated by the RMI Marine Resources Act, which sets minimum size limits for greens (86 cm [34 in] carapace length) and hawksbills (69 cm [27 in] carapace length) and closed seasons from 1 June to 31 August and 1 December to 31 January. Egg collecting and take of turtles while they are onshore is prohibited (Kabua and Edwards 2010). The Marshall Islands Marine Resources Authority manages marine resources in the RMI.

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 near Illeginni Islet has not been measured, and sea turtles in the RMI have not been tested for heavy metal levels in blood or tissues. Damage to coral reefs can reduce foraging habitat for hawksbill turtles, and damage to seagrass beds and declines in seagrass distribution can reduce nearshore foraging habitat for green turtles in the RMI.

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

2.2.1 Green Turtle (*Chelonia mydas*)

Species Description. The green turtle was listed as threatened under the ESA in July 1978 because of excessive commercial harvest, a lack of effective protection, evidence of declining numbers, and habitat degradation and loss (NMFS and USFWS 2007). In March 2015, NMFS and USFWS proposed 11 DPSs globally for the green turtle (Seminoff et al. 2015) the rule was finalized in April 2016 (USFWS and NOAA 2016). Green turtles in the waters of Kwajalein Atoll likely belong to the Central West Pacific DPS (which includes the RMI). The Central West Pacific DPS is listed as Endangered (USFWS and NOAA 2016). Green turtles are mostly herbivorous. They feed primarily on sea grass and algae, at or near the surface in both coastal and open ocean areas (Mortimer 1995). Green turtles spend the majority of their lives in coastal foraging grounds; however, oceanic habitats are used by oceanic-stage juveniles, migrating adults, and occasional foraging adults (NMFS and USFWS 2007).

Distribution. The green turtle is found in tropical and subtropical coastal and open ocean waters of the Atlantic, Pacific, and Indian oceans, generally between 30°N and 30°S (Hirth 1997). There are 6 major nesting populations in the Pacific Ocean and at least 166 smaller nesting sites (NMFS and USFWS 2007, Seminoff et al. 2015, Maison et al. 2010). Green turtle habitat varies by life stage. Hatchlings live in the open ocean for several years. Once reaching the juvenile stage, they congregate in shallower coastal feeding areas (Carr 1987, Bresette et al. 2006). Green turtles spend most of their lives as late juveniles and adults in relatively shallow waters 3 to 10 m (10 to 33 ft) deep with abundant seagrass and algae, near reefs or rocky areas used for resting (NMFS and USFWS 2007). They are highly migratory; both males and females typically migrate seasonally along coastal routes from breeding areas to feeding grounds, while some populations migrate across entire ocean basins (NMFS and USFWS 2007).

Threats. The green sea turtle was listed under the ESA due to excessive commercial harvest, a lack of effective protection, evidence of declining numbers, and habitat degradation and loss (NMFS and USFWS 2007). The harvest of eggs and nesting females for food remains a primary threat to the species across the Pacific Ocean (Maison et al. 2010). In addition, green sea turtles are susceptible to the same potential threats that are generally applicable to all turtle species known to occur in the waters of Kwajalein Atoll.

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

Green turtles nest on several atolls, but Kwajalein Atoll is not a significant nesting area. Based on available information, Seminoff et al. (2015) estimated 300 nesting females in the RMI out of a total of 6,500 nesting females in the Central West Pacific DPS (4.6% of known breeding population). In a 2008 survey of Illeginni Islet, suitable nesting habitat (relatively open sandy beaches and seaward margins of herbaceous strand above tidal influence) for sea turtles was identified (**Figure 3**), and these areas were thoroughly surveyed on foot for nesting pits and tracks. These nesting and haulout habitats were reevaluated during the 2010 inventory and were determined to still be suitable habitat; however, no sea turtle nests or nesting activity have been observed on Illeginni in over 20 years. Sea turtles have been observed hauling out and nesting at the northeastern portion of Kwajalein Islet, including the lagoon side at Emon Beach and the sand berm on the ocean side, approximately east of Emon Beach. However, no sea turtles were observed during the 2008 survey. Three sea turtle nests (species unidentified) were found at Kwajalein Islet in September and October 2010, on a beach on the east-facing shore across the street from the high school (USAF 2015).

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

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

Known green sea turtle activity near Illeginni Islet is limited to the following individual sightings:

- An adult green turtle was seen in nearshore waters on the ocean side of Illeginni in 1996 (USFWS and NMFS 2002);
- An adult turtle of unknown species was documented in the 2006 inventory;
- Four green sea turtles were observed near Illeginni in the 2010 inventory;
- In 2012, one green sea turtle was observed off a lagoon patch reef adjacent to Illeginni Islet;
- An adult green sea turtle was observed during the 2014 inventory in a dense area of seagrass (*Halophila minor*) in Illeginni Harbor; and
- Sea turtle nest pits (unidentified species) were last found on Illeginni Islet in 1996, on the northern tip of the islet. No nesting was observed in surveys completed in 1998, 2000, 2002, 2004, 2006, 2008, or 2010, although suitable sea turtle nesting habitat was observed (USFWS 2011, USFWS and NMFS 2012). Suitable nesting habitat appears northwest and east of the helipad on the lagoon side of Illeginni Islet (**Figure 3**) (USFWS and NMFS 2012).

The reported observations 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.

Figure 3. Suitable Sea Turtle Nesting Habitat on Illeginni Islet, Kwajalein Atoll.

2.2.2 Hawksbill Turtle (*Eretmochelys imbricata*)

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

Distribution. The hawksbill turtle is the most tropical of the world's sea turtles, rarely occurring higher than 30°N or lower than 30°S in the Atlantic, Pacific, and Indian ocean. Abundance estimates are largely based on annual reproductive effort for sea turtle species (NMFS and USFWS 2013b). A lack of nesting beach surveys for hawksbill turtles in the Pacific Ocean and the poorly understood nature of this species' nesting have made it difficult for scientists to assess the population status of hawksbills in the Pacific (NMFS and USFWS 1998a). Surveys of know nesting assemblages in the western and central Pacific Ocean indicate mostly decreasing population trends over the past 20 years (NMFS and USFWS 2013b).

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

Threats. The hawksbill shell has been prized for centuries by artisans and their patrons for jewelry and other adornments. Despite being prohibited under the Convention on International Trade in Endangered Species, trade remains a critical threat to the species (NMFS and USFWS 2013b). Hawksbill turtles are susceptible to the same potential threats that are generally applicable to all turtle species known to occur in the waters of Kwajalein Atoll. In the Pacific, the most significant source of death for hawksbill turtles is direct take of turtles for trade of their shell. These takes generally occur in nearshore marine areas where hawksbills occur.

Populations at Kwajalein Atoll. In the central Pacific, hawksbills are known to nest on beaches in American Samoa, Fiji, the Mariana Archipelago, Micronesia, Palau, the Solomon Islands, and Vanuatu (NMFS and USFWS 2013b). Very little is known about the open ocean distribution of hawksbills in central Pacific Ocean. Hawksbills tend to make short-range movements between nearshore nesting and feeding areas, rather than the long-range open-ocean migrations typical of other sea turtle species (Parker et al. 2009). Overall, Hawksbills in the central Pacific have shown decreasing population trends both in the historic and recent time frames (NMFS and USFWS 2013b).

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

Hawksbill nesting activity was reported on Wotje Islet in 1991 and at Nibung Islet in 1989 (NMFS and USFWS 1998a). In May 2009, a hawksbill nested on the lagoon side of Omelek Islet near the harbor area (Malone 2009). The eggs hatched in early July and were inventoried. Thirteen unhatched eggs and 101 hatched eggs were counted. Two partially hatched turtles were found, and five hatchlings were assisted out of the nest into the ocean. In a 2008 survey of Illeginni Islet, suitable nesting habitat (relatively open sandy beaches and seaward margins of herbaceous strand above tidal influence) for sea turtles was identified on Illeginni Islet (**Figure 3**), and these areas were thoroughly surveyed on foot for nesting pits and tracks. These nesting and haulout habitats were reevaluated during the 2010 inventory and were determined to still be suitable habitat; however, no sea turtle nests or nesting activity have been observed on Illeginni in over 20 years (since 1996).

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

- A hawksbill was observed near shore in the lagoon north of Illeginni in 2002 (USFWS and NMFS 2004);
- An adult hawksbill was observed during a 2004 marine survey of an area extending over the lagoon-facing reef northwest of the harbor to a point across from the northwestern corner of the islet. The survey occurred at depths from 5 to 10 m (16 to 33 ft) (USFWS and NMFS 2006). This high-relief habitat supports a complex community of coral, a foraging area for hawksbills;
- In 2006, a sea turtle (unknown species) was documented near Illeginni Islet;
- An adult hawksbill was observed in the outer lagoon reef flat at Illeginni Islet; and
- Sea turtle nest pits (unidentified species) were last found on Illeginni Islet in 1996, on the northern tip of the islet. No nesting was observed in surveys taken in 1998, 2000, 2002, 2004, 2006, or 2008, although suitable sea turtle nesting habitat was observed (USFWS 2011). Suitable nesting habitat appears northwest and east of the helipad on the lagoon side of Illeginni (**Figure 3**) (USFWS and NMFS 2002).

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

2.3 Fish

The marine environment of Kwajalein Atoll provides a diversity of fish habitat including many reef habitats typical of atolls in the central Pacific, protected lagoon habitats, and deeper ocean habitats surrounding Kwajalein Atoll. There are seven fish species that require consultation under the UES that have the potential to occur in waters of Kwajalein Atoll (**Table 3**). The bigeye thresher shark (*Alopias superciliosus*), oceanic whitetip shark (*Carcharhinus longimanus*), oceanic giant manta ray (*Manta birostris*), and Pacific bluefin tuna (*Thunnus orientalis*) are primarily open ocean species and have the potential to occur in deep ocean waters near Kwajalein Atoll. Relatively little is known about scalloped hammerhead sharks (*Sphyrna lewini*), but this species does have an affinity for coastal environments where it is known to give birth to live young. Juvenile scalloped hammerheads are known to occur in relatively shallow nearshore waters, and adults are known to occur in deeper coastal waters. This species may be found in both nearshore and deeper ocean waters of Kwajalein Atoll. The reef manta ray (*Manta alfredi*) is a shallow water species found primarily in or near reef habitats and may be present near Illeginni Islet. The humphead wrasse (*Cheilinus undulatus*) is reef-associated and found in reef habitat throughout Kwajalein Atoll including the waters surrounding Illeginni Islet.

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

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

Table 3. Fish Species Requiring Consultation under the UES that have the Potential to Occur in Kwajalein Atoll Waters.

Scientific Name	Common Name	UES Consultation Species Listing Status(1)		Likelihood of Occurrence in	
		ESA	UES 3-4.5.1(a)	Deeper Offshore Waters	Nearshore Waters at Illeginni Islet
Alopias superciliosus	Bigeye thresher shark		x	Potential	-
Carcharhinus longimanus	Oceanic whitetip shark	T		Potential	-
Cheilinus undulatus	Humphead wrasse		x	-	Likely
Manta alfredi	Reef manta ray		x	-	Potential
M. birostris	Oceanic giant manta ray	T		Potential	Potential
Sphyrna lewini	Scalloped hammerhead (Indo-West Pacific DPS)	T		Potential	-
Thunnus orientalis	Pacific bluefin tuna		x	Potential	-

Sources: USASMDC/ARSTRAT 2018, NOAA 2020, U.S. Navy 2019

Note:

(1) UES Consultation Species Listing Status based on Appendix 3-4A of the UES (USASMDC/ARSTRAT 2018).
UES Section 3-4.5.1(a): X = Contained in RMI Environmental Protection Agency letter, 12 March 2015, or RMI Environmental Protection Agency letter, 28 September 2016

Abbreviations: DPS = Distinct Population Segment, ESA = U.S. Endangered Species Act, T = ESA Threatened, UES: United States Army Kwajalein Atoll Environmental Standards (USASMDC/ARSTRAT 2018 Section 3-4.5.1).

2.3.1 Bigeye Thresher Shark (*Alopias superciliosus*)

Species Description. This large, broad-headed shark has an elongated upper caudal lobe and distinctive large eyes (NMFS 2015a). Bigeye threshers feed on small to medium sized pelagic fishes, bottom fishes, and cephalopods and use their whip-like tail to stun and disorient prey (NMFS 2015a). Bigeye thresher sharks are ovoviviparous and give birth to 2 to 4 pups after a 12-month gestation (NMFS 2015a). Bigeye thresher sharks reproduce year-round but have low fecundity (Fu et al. 2016). Much of their reproductive phenology remains unknown (NMFS 2015a).

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

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

Populations at Kwajalein Atoll. Little is known about the distribution and abundance of the bigeye thresher shark in the central Pacific. The bigeye thresher is known to occur in deep ocean waters near the Hawaiian Islands (Defenders of Wildlife 2015a) and has also been observed in deep ocean waters of the Marshall Islands (Gilman et al. 2014). The highest densities of bigeye thresher sharks in the Pacific is between 5 and 15°N (Fu et al. 2016). Models of thresher shark density have used an upper bound of two million sharks for the population in the Pacific, which corresponds to a less than 5% chance of encountering more than one shark per square kilometer (km^2) in the areas of highest density (Fu et al. 2016). The bigeye thresher shark is known to occur in the Marshall Islands. Onboard observers of the Marshall Islands longline tuna fishery between 2005 and 2009 documented capture of several shark species including the bigeye thresher shark (Gilman et al. 2014). However, this species has not been documented in the shallow waters near Illeginni Islet.

2.3.2 Oceanic Whitetip Shark (Carcharhinus longimanus)

Species Description. This large, highly migratory shark usually swims at or near the water surface with their huge pectoral fins outspread (Young et al. 2018). Oceanic whitetip sharks feed mainly on teleost fishes and cephalopods but have been known to feed on sea birds, marine mammals, other sharks, mollusks, and crustaceans (Young et al. 2018). This viviparous shark typically gives birth to 1 to 14 pups every other year after a 10 to 12-month gestation period (Young et al. 2018). In U.S. waters of the Pacific, Essential Fish Habitat for the oceanic whitetip shark is defined as the water column down to a depth of 1,000 m (621 ft) from the shoreline to the outer limit of the exclusive economic zone (Young et al. 2018).

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

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

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

2.3.3 Humphead Wrasse (Cheilinus undulatus)

Species Description. The humphead wrasse is found at low densities (one to eight per acre) where it occurs, even in its preferred habitat (Donaldson and Sadovy 2001). Humphead wrasses are observed as solitary male/female pairs or in small groups of two to seven individuals (NMFS 2009). The humphead wrasse is a predator of echinoderms including brittle stars, sea stars, and sea urchins, as well as of mollusks and crustaceans (WildEarth Guardians 2012). The feeding ecology of this wrasse may be beneficial to coral reefs, as their diet includes the crown of thorns starfish, which feeds on coral (WildEarth Guardians 2012). *Cheilinus undulatus* have been observed to aggregate at discrete seaward edges of deep slope drop-offs to broadcast spawn in the water column; they do not deposit their eggs on the substrate (Colin 2010).

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

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

Populations at Kwajalein Atoll. The humphead wrasse is known to occur in nearshore reef habitats at Illeginni Islet (**Table 4**). As was found in other studies (Donaldson and Sadovy 2001), the humphead wrasse appears to occur in low densities throughout Kwajalein Atoll in NMFS and USFWS biennial surveys. Occurrence records of *C. undulatus* suggest a broad, but scattered distribution at Kwajalein Atoll with observations of the species at 26% (32 of 125) of sites at 10 of the 11 surveyed islets since 2010 (**Table 4**). 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 Kwajalein Atoll islets, direct density measures of *C. undulatus* have not been obtained. Two seaward reef flat sites at Illeginni Islet were noted to have adult *C. undulatus* present in 2008 (USFWS 2011).

Table 4. Number of Kwajalein Atoll Survey Sites (2010 to present) with UES Consultation Fish Species Observations.

Family Scientific Name	RN	ET	GA	GL	OM	EK	MK	IL	LG	EN	KI	MAC	Total	Number of Islets
Labridae														
Cheilinus undulatus	4	3	3	1	3	1	1	1	-	3	9	3	32	10
Mobulidae														
Manta sp.[(1)]	-	-	-	-	-	1	-	1	-	-	2	-	4	3
Total Number of Sites Surveyed	13	8	5	8	7	5	8	5	7	5	19	35	125	11

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

Note:

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

Abbreviations: EK = Eniwetak, EN = Ennylabegan, ET = Ennugarett, GA = Gagan, GN = Gellinam, IL = Illeginni, KI = Kwajalein, LG = Legan, MAC = Mid-Atoll Corridor, MK = Meck, OM = Omelek, RN = Roi Namur

Shallow inshore branching coral areas with bushy macro-algae, such as those which may exist along the shallow lagoon reef flat at Illeginni Islet, have been noted as potential essential nursery habitat for juvenile *C. undulatus* (Tupper 2007). Recent settler and juvenile numbers are presumed to greatly exceed 20 in such habitat (Tupper 2007) and might be grossly approximated to range from 0 to 100 within the lagoon-side waters of Illeginni (NMFS 2014).

2.3.4 Reef Manta Ray (Manta alfredi)

Species Description. Until 2009, all manta rays were considered a single species, *Manta birostris*. There are currently two species of manta ray, *M. alfredi* and *M. birostris*, as supported by morphological and genetic data (Marshall et al. 2011a). The giant manta ray is a more oceanic species while the reef manta ray is primarily a nearshore species. Consequently, many historic records of manta rays in nearshore waters likely refer to what is now known as the reef manta ray. While somewhat smaller than the giant manta ray, the reef manta ray is a large, cartilaginous elasmobranch up to 5 m (16.4 ft) long (Marshall et al. 2011a). This species feeds on plankton, which it filters from seawater using gill plates (Defenders of Wildlife 2015b). While long lived, this species exhibits very low fecundity, typically producing only a single pup biennially after a 1-year gestation period (Marshall et al. 2011a). Females are thought to mature at 8 to 10 years, while males are known to breed as early as 6 years of age (Marshall et al. 2011a).

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

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

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

2.3.5 Oceanic Giant Manta Ray (Manta birostris)

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

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

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

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

2.3.6 Scalloped Hammerhead Shark (Sphyrna lewini)

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

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

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

Threats. Both target and bycatch capture in fisheries is a significant cause of mortality for the species. Because scalloped hammerheads aggregate in large schools, large numbers may be captured with minimal effort. They are sought for their highly valuable fins and are being increasingly targeted in some areas. The Indo-West Pacific DPS was proposed for listing as a threatened species (78 FR 20717 [5 April 2013] with high risk due to overutilization by industrial, commercial, and artisanal fisheries as well as illegal and unregulated fishing (Miller et al. 2013).

Populations at Kwajalein Atoll. The scalloped hammerhead sharks scattered distribution in the western Pacific includes all of the tropical/temperate Pacific Islands (Baum et al. 2007). These sharks are considered to be semi-oceanic and occur primarily in coastal areas. Studies of hammerhead shark catches in longline fisheries indicate a limited distribution in the central Pacific with most catches concentrated in deeper waters off the coast of islands (Rice et al. 2015).

At Kwajalein Atoll, a solitary adult scalloped hammerhead shark was observed by NMFS and USFWS biologists in approximately 7.6 m (25 ft) of water seaward of the atoll reef west of Roi-Namur Islet (U.S. Navy 2017). This species may also occur near Illeginni Islet, but there are no available data on occurrence in the waters of Kwajalein Atoll. This species has the potential to occur in the deeper waters around Kwajalein Atoll.

2.3.7 Pacific Bluefin Tuna (Thunnus orientalis)

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

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

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

Populations at Kwajalein Atoll. The density and distribution of this species is poorly understood in the central Pacific. The Pacific bluefin tuna probably occurs in the Marshall Islands (CBD 2016, IUCN 2018). If this species does occur in Kwajalein Atoll, it likely has a patchy and seasonal (though unknown) distribution in deeper waters. This species is not known to occur in nearshore waters of Kwajalein Atoll and there are no known records of Pacific bluefin tuna near Illeginni Islet.

2.4 Corals

The marine environment surrounding Illeginni Islet supports a community of corals that is typical of reef ecosystems in the tropical insular Pacific. In 2014, NMFS surveyed the reef habitats offshore of the DoD test area at Illeginni Islet (**Figure 1**) (NMFS-PIRO 2017a). NMFS estimated that these surveys covered all of the reef habitat area potentially affected by missile impact testing on the lagoon side and 99% of the reef area on the ocean side (NMFS-PIRO 2017a and 2017b). These data are still considered the best available information for coral species presence and density offshore of the terrestrial impact zone at Illeginni Islet. Based on these NMFS surveys (NMFS-PIRO 2017a), seven UES-consultation coral species (*Acropora microclados*, *A. polystoma*, *Cyphastrea agassizi*, *Heliopora coerulea*, *Pavona venosa*, *Pocillopora meandrina*, and *Turbinaria reniformis*) are likely to occur in the reefs near the Illeginni Islet test site as adults.

An additional 15 UES-consultation species that have been observed at other survey locations near Illeginni Islet since 2010 and/or have the potential to occur near in Illeginni Islet nearshore waters as gametes or larvae (see **Table 5**). Four of these species, *Acropora tenella*, *A. vaughani*, *Leptoseris incrustans*, and *Pavona cactus*, occur on lower reef slopes which occur below areas that may be affected by test program impacts on Illeginni Islet, and for this reason, adults are considered unlikely in areas subject to DoD test effects. 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. The other species listed in **Table 5** (*Acanthastrea brevis*, *Acropora aculeus*, *A. aspera*, *A. dendrum*, *A. listeri*, *A. speciosa*, *Alveopora verrilliana*, *Montipora caliculata*, and *Turbinaria stellulata*) have either not been recorded near Illeginni Islet or have been recorded at other locations near Illeginni Islet but have not been recorded in the area potentially affected by impact debris or shock waves (NMFS PIRO 2017a). Adults of these 15 species are considered unlikely in the test area and are not expected to be exposed to stressors from DoD testing.

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

Table 5. Invertebrate Species Requiring Consultation under the UES that have the Potential to Occur near Illeginni Islet.

Scientific Name	Common Name	UES Consultation Species Listing Status(1)			Presence in Areas at Risk from Test Impact Effects Near Illeginni Islet (2)
		ESA	RMI Statute	UES 3-4.5.1(a)	
Corals					
Acanthastrea brevis				x	-
Acropora aculeus				x	-
A. aspera				x	-
A. dendrum				x	-
A. listeri				x	-
A. microclados				x	Ocean Side
A. polystoma				x	Ocean Side
A. speciosa		T			-
A. tenella		T			-
A. vaughani				x	-
Alveopora verrilliana				x	-
Cyphastrea agassizi	Agassiz's coral			x	Lagoon Side
Heliopora coerulea	Blue coral			x	Lagoon Side
Leptoseris incrustans				x	-
Montipora caliculata				x	-
Pavona cactus				x	-
P. decussata				x	-
P. venosa				x	Lagoon Side
Pocillopora meandrina					Ocean Side
Turbinaria mesenterina				x	-
T. reniformis				x	Lagoon Side
T. stellulata				x	-
Mollusks					
Hippopus hippopus	Giant Clam	C			Ocean and Lagoon Sides
Pinctada margaritifera	Black-lipped pearl oyster		3		-
Tectus niloticus(3)	Top shell snail		3		Lagoon Side
Tridacna gigas	Giant Clam	C			-
T. squamosa	Giant Clam	C			Lagoon Side

Sources: USASMDC/ARSTRAT 2018, NOAA 2020, U.S. Navy 2019

Notes:

(1) UES Consultation Species Listing Status based on Appendix 3-4A of the UES (USASMDC/ARSTRAT 2018).
RMI Statutes: 3 = Fisheries Act 1997, Title 51 MIRC Chapter 2;
UES Section 3-4.5.1(a): X = Contained in RMI Environmental Protection Agency letter, 12 March 2015, or RMI Environmental Protection Agency letter, 28 September 2016

(2) Presence based on observations during a 2014 assessment of the reef areas offshore of the Illeginni Islet Impact Zone (NMFS-PIRO 2017a and 2017b) survey areas shown in Figure 1.

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

Abbreviations: C = Species is a candidate for listing under the ESA, ESA = U.S. Endangered Species Act, T = ESA Threatened, UES: United States Army Kwajalein Atoll Environmental Standards, "-" = species was not observed during 2014 surveys.

All shallow-water corals of the Marshall Islands are found throughout much of the insular Pacific and the coral triangle (i.e., the area surrounding Indonesia and the Philippines) (Brown and Wolf 2009). No known shallow-water coral species are endemic to the Marshall Islands. Within Kwajalein Atoll, all coral species found at Illeginni Islet in NMFS/USFWS biennial inventories are found on at least one other Kwajalein Atoll islet (n = 11 islets) (**Table 6**) and at other locations in the Marshall Islands (Beger et al. 2008, Pinca et al. 2002, USFWS and NMFS 2012).

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

Predators of corals include sea stars, snails, and fishes (e.g., crown of thorns sea stars, parrotfish, and butterfly fish) (Boulon et al. 2005, Gulko 1998). Crown of thorns sea stars (*Acanthaster planci*) are the primary predators of most listed coral species known at Illeginni Islet.

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

Coral Reproduction. Most coral species can reproduce both sexually and asexually (NOAA 2017). Most of the shallow-water species requiring consultation in **Table 5** reproduce sexually by spawning, typically from July to December. Some species brood live young, and some coral species engage in both spawning and brooding (Fautin 2002, Gascoigne and Lipcius 2004). Most corals are capable of asexual reproduction by dividing or fragmentation (NOAA 2017). Fragmentation is most often seen in branching corals that are more likely to break (Lirman 2000). Reproductive potential (fecundity) is a function of colony age and size, and many threats to corals reduce reproductive potential by degrees, up to halting reproduction for several years (Boulon et al. 2005, Fautin 2002, Gascoigne and Lipcius 2004, Lirman 2000).

Table 6. Number of Kwajalein Atoll Survey Sites (2010 to present) with UES Consultation Coral Species Observations.

Family Scientific Name	RN	ET	GA	GL	OM	EK	MK	IL	LG	EN	KI	MAC	Total	Number of Islets
Acroporidae														
Acropora aculeus	-	-	-	2	-	1	-	1	2	1	3	3	13	6
A. aspera	4	3	1	1	2	-	2	1	1	-	9	1	25	9
A. dendrum	-	-	1	1	2	2	4	1	1	1	7	5	25	9
A. listeri	-	-	1	1	-	1	2	-	1	-	2	2	10	6
A. microclados	3	3	4	6	6	5	8	5	7	5	16	34	102	11
A. polystoma	1	-	2	1	-	-	1	-	1	-	3	1	10	6
A. speciosa	-	1	-	-	-	-	2	-	-	-	4	4	11	3
A. tenella	1	-	-	-	-	-	1	1	-	1	5	1	10	5
A. vaughani	2	3	3	3	2	1	2	2	-	-	7	4	29	9
Montipora caliculata	2	4	2	7	5	4	8	5	6	2	6	31	82	11
Agariciidae														
Leptoseris incrustans	3	2	-	4	2	1	2	2	2	1	5	25	49	10
Pavona cactus	2	3	3	1	3	-	4	2	-	-	10	4	32	8
P. decussata	1	-	-	-	-	-	1	1	-	2	1	1	7	5
P. venosa	1	1	3	1	1	1	2	2	2	3	7	16	40	11
Dendrophylliidae														
Turbinaria mesenterina	1	-	1	-	1	-	-	1	1	-	-	-	5	5
T. reniformis	4	3	2	4	2	3	1	4	2	1	2	9	37	11
T. stellulata	3	2	1	1	-	-	-	3	1	-	-	9	20	6
Faviidae														
Cyphastrea agassizi	-	2	1	1	4	2	4	3	2	-	2	14	35	9
Helioporidae														
Heliopora coerulea	3	2	1	6	4	5	5	4	7	2	5	32	76	11
Mussidae														
Acanthastrea brevis	2	-	2	-	1	1	3	4	5	2	4	23	47	9
Pocilloporidae														
Pocillopora meandrina	11	5	5	8	7	5	8	5	7	5	19	35	120	11
Portidae														
Alveopora verrilliana	-	-	-	1	-	-	-	2	1	-	2	10	16	4
Total Number of Sites or Islets Surveyed	13	8	5	8	7	5	8	5	7	5	19	35	125	11

Sources: USFWS and NMFS 2012, NMFS and USFWS 2013a, NMFS and USFWS 2017, NMFS and USFWS 2018

Abbreviations: EK = Eniwetak, EN = Ennylabegan, ET = Ennugarett, GA = Gagan, GN = Gellinam, IL = Illeginni, KI = Kwajalein, LG = Legan, MAC = Mid-Atoll Corridor, MK = Meck, OM = Omelek, RN = Roi Namur

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

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

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

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

There are no known species-specific threats for any particular coral species listed in **Table 5**, although it is conceivable that some diseases are species specific. Some groups of corals are more or less susceptible to predation and general threats. For example, the predatory crown of thorns sea star (*Acanthaster planci*) feeds preferentially, but not exclusively, on *Acropora* and *Pocillopora* species (Gulko 1998). A type of "white" disease seems to preferentially affect tabular colonies of *Acropora* (Beger et al. 2008). The aquarium industry has various taxa-specific preferences and, as one of the more profitable industries in the RMI, is a potential contributor to loss of preferred populations (Pinca et al. 2002).

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

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

2.4.1 Acanthastrea brevis

Species Description. *Acanthastrea brevis* is a uniform or mottled brown, yellow, or green hard coral species in the family Mussidae with a spiny appearance (Vernon et al. 2016). This species is generally not fleshy and colonies are mostly submassive (Vernon et al. 2016).

Distribution. *Acanthastrea brevis* is found in the Red Sea and Gulf of Aden, the Southwest Indian Ocean, Northern Indian Ocean, the Central Indo-Pacific, the Oceanic West Pacific, the Great Barrier Reef, and Fiji (Brown and Wolf 2009). This range includes the waters of American Samoa, Micronesia, the Northern Mariana Islands, and Palau (Brown and Wolf 2009). *Acanthastrea brevis* is found in all types of reef habitat at depths of 1 to 20 m (3 to 66 ft) (Brown and Wolf 2009).

Threats. This species is particularly susceptible to crown-of-thorns starfish, which is a significant threat to many corals throughout the Indo-Pacific (Brown and Wolf 2009). Due to this and other general coral threats listed above, this species is declining and has an estimated reduction in habitat of 36% over 30 years (Brown and Wolf 2009).

Populations near Illeginni Islet. *Acanthastrea brevis* has been observed at 6 of the 11 surveyed Kwajalein Atoll islets since 2010 (**Table 6**). In addition to Illeginni Islet, it has been observed during inventories at Kwajalein, Roi-Namur, Meck, Gagan, and Eniwetak islets as well as on reefs in the Mid-Atoll Corridor. Overall, *A. brevis* has been observed at 38% (47 of 125) of survey sites in Kwajalein Atoll. This species was observed at 60% (4 of 5) of biennial inventory sites at Illeginni Islet since 2010 including a site in Illeginni Harbor but was not observed in the 2014 surveys near the Illeginni Islet terrestrial impact zone.

2.4.2 Acropora aculeus

Species Description. *Acropora aculeus* is a gray, bright blue-green, or yellow hard coral species with tips that are yellow, lime green, pale blue, or brown in the family Acroporidae (Vernon et al. 2016). *Acropora aculeus* forms colonies of corymbose clumps with thin, spreading horizontal branches and fine, upward projecting branchlets (Brown and Wolf 2009).

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

Threats. This species is particularly susceptible to crown-of-thorns starfish, which is a serious threat to many corals throughout the Indo-Pacific (Brown and Wolf 2009). Like other *Acropora* species, *A. aculeus* is susceptible to bleaching and disease and is slow to recover (Brown and Wolf 2009). Aquarium harvest and extensive habitat reduction are also significant threats to this species (Brown and Wolf 2009). Due to these and other general coral threats listed above, this species is declining and has an estimated habitat loss and population reduction of 37% over 30 years (Brown and Wolf 2009).

Populations near Illeginni Islet. *Acropora aculeus* has been observed at 6 of the 11 surveyed Kwajalein Atoll islets since 2010 (**Table 6**). In addition to Illeginni, it has been observed during inventories at Kwajalein, Ennylabegan, Eniwetak, Gellinam, and Legan islets as well as on reefs in the Mid-Atoll Corridor. Overall, *A. aculeus* has been observed at 10% (13 of 125) survey sites in Kwajalein Atoll. This species was observed at 20% (1 of 5) of biennial inventory sites at Illeginni Islet since 2010 but was not observed in the 2014 surveys near the Illeginni Islet impact zone.

2.4.3 Acropora aspera

Species Description. *Acropora aspera* is a pale blue-gray, green, cream, or bright blue species in the family Acroporidae (Vernon et al. 2016). This species is found in thick-branching corymbose colonies that vary in length due to wave action (Vernon et al. 2016).

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

Threats. Like many other *Acropora* species, *A. apera* is susceptible to predation by crown-of-thorns starfish, bleaching, and disease and is slow to recover (Brown and Wolf 2009). Aquarium harvest and extensive habitat reduction and degradation are also significant threats to this species (Brown and Wolf 2009). Due to these and other general coral threats listed above, this species is declining and has an estimated habitat loss of 37% over 30 years (Brown and Wolf 2009).

Populations near Illeginni Islet. *Acropora aspera* has been observed at 9 of the 11 surveyed Kwajalein Atoll islets since 2010 as well as on reefs in the Mid-Atoll Corridor (**Table 6**). This species has been observed only in harbor surveys at Illeginni islet (20% of sites, 1 of 5 sites) and was not observed during 2014 surveys near the Illeginni Islet impact zone. Overall, *A. aspera* has been observed at 20% (25 of 125) survey sites in Kwajalein Atoll since 2010.

2.4.4 Acropora dendrum

Species Description. *Acropora dendrum* is a pale brown or cream colored hard coral species in the family Acroporidae (Vernon et al. 2016). *Acropora dendrum* forms colonies of corymbose plates that are 0.5 to 1 m (1.6 to 3.3 ft) across and have widely spaced, tapering branchlets (Vernon et al. 2016).

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

Threats. This species is particularly susceptible to crown-of-thorns starfish, which is a serious threat to many corals throughout the Indo-Pacific (Brown and Wolf 2009). Like other *Acropora* species, *A. dendrum* is susceptible to bleaching and disease and is slow to recover (IU Brown and Wolf 2009). Aquarium harvest and extensive habitat reduction and degradation are also significant threats to this species (Brown and Wolf 2009). Due to these and other general coral threats listed above, this species is declining and has an estimated habitat loss and population reduction of 35% over 30 years (Brown and Wolf 2009).

Populations near Illeginni Islet. *Acropora dendrum* has been observed at 9 of the 11 surveyed Kwajalein Atoll islets since 2010 (**Table 6**). In addition to Illeginni, it has been observed during inventories at Kwajalein, Meck, Omelek, Legan, Gagan, Eniwetak, Ennylabegan, and Gellinam islets as well as on reefs in the Mid-Atoll Corridor. Overall, *A. dendrum* has been observed at 20% (25 of 125) survey sites in Kwajalein Atoll. This species was observed at 20% (1 of 5) of biennial inventory sites at Illeginni Islet since 2010 (**Table 6**) but was not observed in the 2014 surveys offshore of the Illeginni Islet impact zone.

2.4.5 Acropora listeri

Species Description. *Acropora listeri* is a cream or brown colored hard coral species in the family Acroporidae (Vernon et al. 2016). *Acropora listeri* forms colonies of irregular clumps or corymbose plates with thick, highly irregular branches that may vary in form depending on wave action (Vernon et al. 2016).

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

Threats. Like other *Acropora* species, *A. listeri* is susceptible to predation by crown-of-thorns starfish, bleaching, and disease and is slow to recover from disturbance events (Brown and Wolf 2009). Aquarium harvest and extensive habitat reduction and degradation are also significant threats to this species (Brown and Wolf 2009). Due to these and other general coral threats listed above, this species is declining and has an estimated habitat loss and population reduction of 35% over 30 years (Brown and Wolf 2009).

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

2.4.6 Acropora microclados

Species Description. *Acropora microclados*, in the family Acroporidae, is a pale pinkish-brown colored hard coral species with pale gray tentacles (Vernon et al. 2016). *Acropora microclados* forms colonies of corymbose plates that are up to 1 m (3.3 ft) across and have short, uniform, tapered branchlets that are up to 10 mm (0.4 inch) thick at their bases (Vernon et al. 2016).

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

Threats. This species is particularly susceptible to crown-of-thorns starfish, which is a serious threat to many corals throughout the Indo-Pacific (Brown and Wolf 2009). Like other *Acropora* species, *A. microclados* is susceptible to bleaching and disease and is slow to recover (Brown and Wolf 2009). Aquarium harvest and extensive habitat reduction and degradation are also significant threats to this species (Brown and Wolf 2009). Due to these and other general coral threats listed above, this species is declining and has an estimated habitat loss and population reduction of 33% over 30 years (Brown and Wolf 2009).

Populations near Illeginni Islet. During NMFS surveys of the reef habitats offshore of the terrestrial impact zone at Illeginni Islet, this species was observed at very low densities in ocean-side reef areas (**Table 7**, NMFS-PIRO 2017a). *Acropora microclados* has been observed at all 11 of the surveyed Kwajalein Atoll islets since 2010 and on reefs in the Mid-Atoll Corridor (**Table 6**). Overall, *A. microclados* has been observed at 82% (102 of 125) survey sites in Kwajalein Atoll. This species was observed at 100% (5 of 5) of sites at Illeginni Islet since 2008 including in Illeginni Harbor.

Table 7. Density Estimates for UES Consultation Coral and Mollusk Species in Reef Habitats Offshore of the Illeginni Islet Impact Zone.

Species	Ocean Side Survey Area		Lagoon Side Survey Area	
	Mean Colonies or Individuals (per m^2)	99% UCL (per m^2)	Mean Colonies or Individuals (per m^2)	99% UCL (per m^2)
Corals				
Acropora microclados	0.0004	0.0017		
Acropora polystoma	≤0.0004	0.0017		
Cyphastrea agassizi			0.0003	0.0013
Heliopora coerulea			0.16	0.45
Pavona venosa			0.0003	0.0013
Pocillopora meandrina	0.3	0.58		
Turbinaria reniformis			≤0.0003	0.0013
Mollusks				
Hippopus hippopus	0.0003	0.0015	0.002	0.006
Tectus niloticus			0.00006	0.0003
Tridacna squamosa			0.0002	0.0011

Sources: NMFS-PIRO 2017a and 2017b, Kolinski 2018 personal communication.
Abbreviations: m^2 = square meter, UCL = upper confidence limit

2.4.7 Acropora polystoma

Species Description. This species in the family Acroporidae is a cream, blue, or yellow colored hard coral species (Vernon et al. 2016). *Acropora polystoma* forms colonies of irregular clumps or corymbose plates with tapered, uniform branches (Vernon et al. 2016).

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

Threats. Like other *Acropora* species, *A. polystoma* is susceptible to predation by crown-of-thorns starfish, bleaching, and disease and is slow to recover (Brown and Wolf 2009). Aquarium harvest and extensive habitat reduction and degradation are also significant threats to this species (Brown and Wolf 2009). This species has also been reported to have severe white-band/white-plague disease, which affects reproduction and can have devastating regional impacts. Due to these and other general coral threats listed above, this species is declining and has an estimated habitat loss and population reduction of 35% over 30 years (Brown and Wolf 2009).

Populations near Illeginni Islet. During NMFS surveys of the reef habitats offshore of the terrestrial impact zone at Illeginni Islet, this species was observed at very low densities in ocean-side reef areas (**Table 7**, NMFS-PIRO 2017a). *Acropora polystoma* has been observed at 6 of the 11 Kwajalein Atoll islets and on reefs in the Mid-Atoll Corridor since 2010. Though not observed during surveys at Illeginni islet, this species has been observed near Kwajalein, Legan, Meck, Gellinam, Gagan, and Roi Namur islets. Overall, *A. polystoma* has been observed at 8% (10 of 125) survey sites in Kwajalein Atoll (**Table 6**).

2.4.8 Acropora speciosa

Species Description. *Acropora speciosa* was listed as a threatened species under the ESA in August 2014. This species in the family Acroporidae has cream-colored colonies consisting of thick cushions and bottlebrush branches with contrasting corallite tips (Vernon et al. 2016).

Distribution. *Acropora speciosa* occurs in the Central Indo-Pacific, Australia, Southeast Asia, the Central Pacific, New Caledonia, the Philippines, Fiji, Sarawak, Ban Ngai, Papua New Guinea, Western Samoa, and the Oceanic West Pacific (Brown and Wolf 2009). This range includes the waters of American Samoa, the Marshall Islands, Micronesia, and Palau (Brown and Wolf 2009). *Acropora speciosa* is found in protected reef environments with clear water and high *Acropora* diversity and also occurs subtidally on walls and steep slopes in deep or shaded shallow conditions (Brown and Wolf 2009). This species is typically found at depths of 12 to 30 m (39 to 98 ft) (Brown and Wolf 2009).

Threats. This species exhibits a decreasing population trend and like other *Acropora* species, *A. speciosa* is particularly susceptible to bleaching, disease, crown-of-thorns starfish predation, trade, and habitat degradation (Brown and Wolf 2009). Due to these and other general coral threats listed above, this species is declining and has an estimated habitat loss and population reduction of 35% over 30 years (Brown and Wolf 2009).

Populations in near Illeginni Islet. *Acropora speciosa* has been observed at 3 of the 11 surveyed Kwajalein Atoll islets since 2010 and has also been observed at sites in the Mid-Atoll Corridor (**Table 6**). Overall, *A. speciosa* has been observed at only 9% (11 of 125) survey sites in Kwajalein Atoll. This species has not observed at biennial survey sites at Illeginni Islet and was not observed during 2014 surveys of the area offshore of the Illeginni Islet impact zone. Since *A. speciosa* is a deeper dwelling species, it occurs below areas that have the potential to be affected by test impacts on Illeginni islet as an adult.

2.4.9 Acropora tenella

Species Description. *Acropora tenella* was listed as a threatened species under the ESA in August 2014. This species in the family Acroporidae has colonies consisting of horizontal plates or flattened branches with white or blue tips that either fan out or form irregular tangles (Vernon et al. 2016).

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

Threats. This species is particularly susceptible to crown-of-thorns starfish, which is a serious threat to many corals throughout the Indo-Pacific (Brown and Wolf 2009). Like other *Acropora* species, *A. tenella* is susceptible to bleaching and disease and is slow to recover (Brown and Wolf 2009). Aquarium harvest and extensive habitat reduction and degradation are also significant threats to this species (Brown and Wolf 2009). Due to these and other general coral threats listed above, this species is declining and has an estimated habitat loss and population reduction of 39% over 30 years (Brown and Wolf 2009).

Populations near Illeginni Islet. *Acropora tenella* has been observed at 2 of the 11 Kwajalein Atoll islets since 2008. In addition to Illeginni Islet, it has been observed during inventories at Kwajalein Islet and on reefs in the Mid-Atoll Corridor. Overall, *A. tenella* has been observed at only 7% (7 of 95) survey sites in Kwajalein Atoll. This species was observed at 25% (1 of 4) of sites at Illeginni Islet since 2008. However, since *A. tenella* is a deeper dwelling species, it was not observed during 2014 surveys of the marine habitats offshore of the terrestrial impact zone on Illeginni Islet.

2.4.10 Acropora vaughani

Species Description. *Acropora vaughani* is a blue, cream, or pale brown colored hard coral species in the family Acroporidae (Vernon et al. 2016). This species forms open branched colonies with a bushy appearance due to compact branchlets protruding from the main branches (Vernon et al. 2016).

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

Threats. This species is particularly susceptible to crown-of-thorns starfish, which is a serious threat to many corals throughout the Indo-Pacific (Brown and Wolf 2009). Like other *Acropora* species, *A. vaughani* is susceptible to bleaching and disease and is slow to recover (Brown and Wolf 2009). Aquarium harvest and extensive habitat reduction and degradation are also significant threats to this species (Brown and Wolf 2009). Due to these and other general coral threats listed above, this species is declining and has an estimated habitat loss and population reduction of 35% over 30 years (Brown and Wolf 2009).

Populations near Illeginni Islet. *Acropora vaughani* has been observed at 9 of the 11 surveyed Kwajalein Atoll islets since 2010 (**Table 6**). In addition to Illeginni, it has been observed during inventories at Kwajalein, Roi-Namur Omelek, Gagan, Gellinam, Eniwetak, Meck, and Ennugarett islets as well as on reefs in the Mid-Atoll Corridor. Overall, *A. vaughani* has been observed at 23% (29 of 125) survey sites in Kwajalein Atoll. This species was observed at 40% (2 of 5) of sites at Illeginni Islet since 2010 including during surveys of Illeginni Harbor (**Table 6**). However, since A. vaughani is a deeper dwelling species, it was not observed during 2014 surveys of the marine habitats offshore of the terrestrial impact zone on Illeginni Islet.

2.4.11 Alveopora verrilliana

Species Description. *Alveopora verrilliana* is a dark greenish-brown, gray, or chocolate brown colored hard coral species in the family Acroporidae (Vernon et al. 2016). *Alveopora verrilliana* forms hemispherical colonies with short, irregularly dividing, knob-like branches (Vernon et al. 2016).

Distribution. *Alveopora verrilliana* is uncommon but found in the Red Sea and Gulf of Aden, the Northern Indian Ocean, Central Indo-Pacific, Australia, Southeast Asia, Japan and the East China Sea, the Oceanic West Pacific, the Central Pacific, and the Southern Mariana Islands (Brown and Wolf 2009). This range includes the waters of American Samoa, Micronesia, the Marshall Islands, the Northern Mariana Islands, Palau, and Johnston Atoll (Brown and Wolf

2009). This species is found in reef environments at depths of up to 30 m (98 ft) (Brown and Wolf 2009).

Threats. Like other *Alveopora* species, *A. verrilliana* is susceptible to bleaching and harvest for the aquarium trade (Brown and Wolf 2009). Due to these and other general coral threats listed above, this species has an estimated habitat loss and population reduction of 35% over 30 years, however, recent population trends are unknown (Brown and Wolf 2009).

Populations near Illeginni Islet. *Alveopora verrilliana* has been observed at 4 of the 11 surveyed Kwajalein Atoll islets since 2010 (**Table 6**). In addition to Illeginni, it has been observed during inventories at Kwajalein, Gellinam, and Legan islets as well as on reefs in the Mid-Atoll Corridor. Overall, *A. verrilliana* has been observed at 13% (16 of 125) survey sites in Kwajalein Atoll. This species was observed at 40% (2 of 5) of the biennial survey sites at Illeginni Islet since 2010 (**Table 6**) but was not observed during 2014 surveys of the area offshore of the terrestrial impact zone at Illeginni Islet.

2.4.12 Cyphastrea agassizi

Species Description. This species in the family Faviidae is a pale brown or green colored coral species (Vernon et al. 2016). This species forms massive colonies that are only a few inches in diameter with deeply grooved surfaces and widely spaced corallites (Vernon et al. 2016).

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

Threats. This species is particularly susceptible to bleaching, disease, and habitat reduction throughout its range (Brown and Wolf 2009). Due to these and other general coral threats listed above, this species is declining and has an estimated habitat loss and population reduction of 36% over 30 years (Brown and Wolf 2009).

Populations near Illeginni Islet. During NMFS surveys of the reef habitats offshore of the terrestrial impact zone at Illeginni Islet, this species was observed at low densities in lagoon-side reef areas (**Table 7**, NMFS-PIRO 2017a). *Cyphastrea agassizi* has been observed at 9 of the 11 surveyed Kwajalein Atoll islets since 2010 as well as on reefs in the Mid-Atoll Corridor (**Table 6**). Overall, *C. agassizi* has been observed at 28% (35 of 125) survey sites in Kwajalein Atoll. This species was observed at 60% (3 of 5) of sites at Illeginni Islet since 2010 including in Illeginni Harbor in 2014.

2.4.13 Heliopora coerulea

Species Description. This species, in the family Helioporidae, is a blue or greenish stony, non-scleractinian coral species that has a permanently blue skeleton (Vernon et al. 2016). *Heliopora coerulea* has polyps with eight tentacles and demonstrates significant variability in growth form based on habitat (Vernon et al. 2016).

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

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

Populations near Illeginni Islet. During NMFS surveys of the reef habitats offshore of the terrestrial impact zone at Illeginni Islet, this species was observed in lagoon-side reef areas (**Table 7**, NMFS-PIRO 2017a). *Heliopora coerulea* has been observed at all 11 of the surveyed Kwajalein Atoll islets since 2010 as well as on reefs in the Mid-Atoll Corridor (**Table 6**). Overall, *H. coerulea* has been observed at 61% (76 of 125) survey sites in Kwajalein Atoll. This species was observed at 80% (4 of 5) of sites at Illeginni Islet since 2010.

2.4.14 Leptoseris incrustans

Species Description. *Leptoseris incrustans* is a small, pale to dark brown or greenish-brown hard coral species in the family Agariciidae (Vernon et al. 2016). Colonies of this species are usually encrusting, though sometimes they develop broad explanate laminae with radiating ridges (Vernon et al. 2016). This species also has small, compacted columellae and superficial corallites with a secondary radial symmetry (Vernon et al. 2016).

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

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

Populations near Illeginni Islet. *Leptoseris incrustans* has been observed at 10 of the 11 surveyed Kwajalein Atoll islets since 2010 as well as on reefs in the Mid-Atoll Corridor (**Table 6**). Overall, *L. incrustans* has been observed at 39% (49 of 125) survey sites in Kwajalein Atoll. This species was observed at 40% (2 of 5) of biennial survey sites at Illeginni Islet since 2010 but was not observed in the 2014 surveys offshore of the Illeginni Islet impact zone.

2.4.15 Montipora caliculata

Species Description. *Montipora caliculata* is a brown or blue coral species in the family Acroporidae (Vernon et al. 2016). *Montipora caliculata* forms massive colonies with a mixture of immersed and funnel-shaped corallites; the latter generally have wavy rims (Vernon et al. 2016).

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

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

Populations near Illeginni Islet. *Montipora caliculata* has been observed at all 11 of the surveyed Kwajalein Atoll islets since 2010 as well as well as on reefs in the Mid-Atoll Corridor (**Table 6**). Overall, *M. caliculata* has been observed at 66% (82 of 125) survey sites in Kwajalein Atoll. This species was observed at 100% (5 of 5) of biennial survey sites at Illeginni Islet since 2010 including in Illeginni Harbor (**Table 6**) but was not observed in the 2014 surveys offshore of the Illeginni Islet impact zone.

2.4.16 Pavona cactus

Species Description. *Pavona cactus* is a pale brown or greenish-brown coral species with white margins in the family Agariciidae (Vernon et al. 2016). *Pavona cactus* forms colonies with thin, contorted, bifacial, upright fronds with sometimes-thickened branching bases (Vernon et al. 2016).

Distribution. *Pavona cactus* is found throughout the Red Sea and Gulf of Aden, the Persian and Arabian Gulfs, the Southwest and Central Indian Ocean, Central Indo-Pacific, Australia, Southern Japan and the South China Sea, the Oceanic West Pacific, and the Central Pacific

(Brown and Wolf 2009). This range includes the waters of American Samoa, Micronesia, the Marshall Islands, the Northern Mariana Islands and Palau (Brown and Wolf 2009). This species is found in lagoons and on upper reef slopes, especially those of fringing reefs, and in turbid water protected from wave action at depths of 3 to 20 m (10 to 66 ft) (Brown and Wolf 2009).

Threats. *Pavona cactus* is susceptible to bleaching, extensive reduction of reef habitat, and aquarium harvest (Brown and Wolf 2009). Due to these and other general coral threats listed above, this species is declining and has an estimated habitat loss and population reduction of 36% over 30 years (Brown and Wolf 2009).

Populations near Illeginni Islet. *Pavona cactus* has been observed at 8 of the 11 surveyed Kwajalein Atoll islets since 2010. In addition to Illeginni, it has been observed during inventories at Kwajalein, Roi Namur, Meck, Omelek, Gagan, Gellinam, and Ennugarett islets as well as on reefs in the Mid-Atoll Corridor. Overall, *Pavona cactus* has been observed at 26% (32 of 125) survey sites in Kwajalein Atoll. This species was observed at 40% (2 of 5) of sites at Illeginni Islet since 2010 including in Illeginni Harbor (**Table 6**). However, since *A. vaughani* is a deeper dwelling species, it occurs below the 2014 survey areas offshore of the Illeginni Islet terrestrial impact zone and was not observed during those surveys.

2.4.17 Pavona decussata

Species Description. *Pavona decussata* is a brown, creamy-yellow, or greenish color coral with colonies that grow into thick, upright plates in the family Agariciidae (Brainard et al. 2011). These variable shaped colonies can grow to several meters across (Brown and Wolf 2009).

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

Threats. *Pavona decussata* is susceptible to bleaching, disease, ocean acidification, fisheries, and extensive reduction of reef habitat; however, its current population trend is unknown (Brown and Wolf 2009). Due to these and other general coral threats listed above, this species has an estimated habitat loss and population reduction of 36% over 30 years (Brown and Wolf 2009).

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

2.4.18 *Pavona venosa*

Species Description. *Pavona venosa* is in the family Agariciidae and is a yellowish- or pinkish-brown coral that is sometimes mottled (Vernon et al. 2016). This species forms massive to encrusting colonies that are generally less than 50 cm (20 inches) in diameter with sunken corallites arranged in short valleys (Vernon et al. 2016, Brown and Wolf 2009).

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

Threats. *Pavona venosa* is susceptible to bleaching, disease, and extensive reduction of reef habitat; however, its current population trend is unknown (Brown and Wolf 2009). Due to these and other general coral threats listed above, this species has an estimated habitat loss and population reduction of 37% over 30 years (Brown and Wolf 2009).

Populations near Illeginni Islet. During NMFS surveys of reef habitats offshore of the terrestrial impact zone at Illeginni Islet, this species was observed at very low densities in lagoon-side reef areas (**Table 7**, NMFS-PIRO 2017a). *Pavona venosa* has been observed at all 11 of the surveyed Kwajalein Atoll islets since 2010 as well as on reefs in the Mid-Atoll Corridor (**Table 6**). Overall, *P. venosa* has been observed at 32% (40 of 125) survey sites in Kwajalein Atoll. This species was observed at 40% (2 of 5) of sites at Illeginni Islet since 2010.

2.4.19 *Pocillopora meandrina*

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

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

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

Populations near Illeginni Islet. During NMFS surveys of the reef habitats offshore of the terrestrial impact zone at Illeginni Islet, this species was observed at relatively high densities in ocean-side reef areas (**Table 7**, NMFS-PIRO 2017a). *Pocillopora meandrina* has been observed at all 11 of the surveyed Kwajalein Atoll islets since 2010 as well as in the Mid-Atoll Corridor (**Table 6**). 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.

2.4.20 Turbinaria mesenterina

Species Description. *Turbinaria mesenterina* is a gray-green or gray-brown coral in the family Dendrophylliidae (Brainard et al. 2011). *Turbinaria mesenterina* colonies form large “lettuce-like” assemblages of variable plates depending on wave motion and light conditions (Brainard et al 2011). Colonies of *T. mesenterina* are generally less than one meter in diameter but can be much larger on fringing reefs (Brown and Wolf 2009).

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

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

Populations near Illeginni Islet. *Turbinaria mesenterina* has been observed at 5 of the 11 surveyed Kwajalein Atoll islets since 2010 (**Table 6**). In addition to Illeginni, it has been observed during inventories at Roi Namur, Gagan, Omelek, and Legan islets as well as on reefs in the Mid-Atoll Corridor. Overall, *T. mesenterina* has been observed at 4% (5 of 125) survey sites in Kwajalein Atoll. At Illeginni Islet, this species was only observed in Illeginni Harbor (20% of Illeginni sites) since 2010 and is not known or expected to occur in reef habitat on the western end of Illeginni Islet.

2.4.21 Turbinaria reniformis

Species Description. This species in the family Dendrophylliidae is a yellow-green coral with contrasting colored margins (Vernon et al. 2016, Brown and Wolf 2009*). Turbinaria reniformis* colonies form large stands on fringing reefs where water is turbid and unifacial laminae sometimes form horizontal tiers (Brown and Wolf 2009).

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

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

Populations near Illeginni Islet. During NMFS surveys of the reef habitats offshore of the terrestrial impact zone at Illeginni Islet, this species was observed at very low densities in lagoon-side reef areas (**Table 7**, NMFS-PIRO 2017a). *Turbinaria reniformis* has been observed at all 11 of the surveyed Kwajalein Atoll islets since 2010 as well as on reefs in the Mid-Atoll Corridor (**Table 6**). Overall, *T. reniformis* has been observed at 30% (37 of 125) survey sites in Kwajalein Atoll. This species was observed at 80% (4 of 5) of sites at Illeginni Islet since 2010.

2.4.22 Turbinaria stellulata

Species Description. *Turbinaria stellulata* is most frequently a brown or green coral but has a wide range of colors (Vernon et al. 2016). *Turbinaria stellulata* is in the family Dendrophylliidae and forms colonies less than 50 cm (20 in) in diameter that are primarily encrusting and sometimes dome-shaped (Vernon et al. 2016).

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

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

Populations near Illeginni Islet. *Turbinaria stellulata* has been observed at 6 of the 11 Kwajalein Atoll islets since 2010 (**Table 6**). In addition to Illeginni, it has been observed during inventories at Roi Namur, Legan, Gagan, Gellinam, and Ennugarett islets as well as on reefs in the Mid-Atoll Corridor. Overall, *T. stellulata* has been observed at 16% (20 of 125) survey sites in Kwajalein Atoll. This species was observed at 60% (3 of 5) of sites at Illeginni Islet since 2010 (**Table 6**) but was not observed in the 2014 surveys offshore of the Illeginni Islet impact zone.

2.5 Mollusks

Five mollusk species that require consultation under the UES have the potential to occur near Illeginni Islet (**Tables 5 and 8**). In 2014, NMFS surveyed the reef habitats offshore of the terrestrial impact zone at Illeginni Islet (**Figure 1**) (NMFS-PIRO 2017b). NMFS estimated that these surveys covered all of the reef habitat area potentially affected by missile impact testing on the lagoon side and 99% of the reef area on the ocean side (NMFS-PIRO 2017b). These data are still considered the best available information for consultation mollusk species presence and density in the area potentially impacted by testing on Illeginni Islet. Based on these NMFS surveys (NMFS-PIRO 2017b), three UES-consultation mollusk species (*Hippopus hippopus*, *Tectus niloticus*, and *Tridacna squamosa*) are likely to occur near the Illeginni Islet test site as adults. Two additional UES-consultation species, *Pinctada margaritifera* and *Tradacna gigas*, have the potential to occur in the Illeginni Islet nearshore area as adults but are considered very unlikely.

Pinctada margaritifera and *Tradacna gigas* have not been recorded in the area of potential effect offshore of Illeginni Islet and are not likely to occur in this area as adults. The black-lipped pearl oyster (*Pinctada margaritifera*) has been observed on the lagoon-side reef slope during biennial resource surveys at Illeginni Islet (**Table 8**) but is a reef slope dwelling species, that occurs below the areas that have the potential to be affected by testing on Illeginni Islet. The giant clam *Tridacna gigas* has been observed at biennial survey locations at Illeginni Islet and throughout Kwajalein Atoll but has not been observed in habitats near the terrestrial impact zone on Illeginni Islet (NMFS-PIRO 2017a and 2017b).

Larvae of all the mollusk species listed in **Table 8** have the potential to occur in Illeginni Islet nearshore waters; however, larval concentrations are likely very low and a small fraction of the total larval pool at Kwajalein Atoll. Additional information about mollusk reproduction can be found in the subsections below. Due to the short time between fertilization and settlement in these mollusk species and their time-limited dispersal capability, the abundance of mollusk larvae (especially viable larvae) is likely extremely low in the Illeginni Islet nearshore area.

Table 8. Number of Kwajalein Atoll Survey Sites (2010 to present) with UES Consultation Mollusk Species Observations.

Family Scientific Name	RN	ET	GA	GL	OM	EK	MK	IL	LG	EN	KI	MAC	Total	Number of Islets
Cardiidae														
Hippopus hippopus	7	3	3	4	4	1	1	2	5	1	7	9	47	11
Tridacna gigas	1	1	2	2	1	2	2	2	2	1	1	11	28	11
T. squamosa	2	2	-	4	4	4	3	3	4	2	-	24	52	9
Pteriidae														
Pinctada margaritifera	2	2	1	-	-	1	2	1	1	-	6	-	16	8
Tegulidae														
Tectus niloticus(1)	8	6	5	4	4	2	3	5	7	5	18	12	79	11
Total Number of Sites Surveyed	13	8	5	8	7	5	8	5	7	5	19	35	125	11

Sources: USFWS and NMFS 2012, NMFS and USFWS 2013a, NMFS and USFWS 2017, NMFS and USFWS 2018

Note:

(1) Within RMI legislation *Tectus niloticus* is inclusive of *Trochus maximus*, *Trochus niloticus*, and *Tectus maximus*. This taxon is currently most commonly synonymized under the name *Tectus niloticus*.

Abbreviations: EK = Eniwetak, EN = Ennylabegan, ET = Ennugarett, GA = Gagan, GN = Gellinam, IL = Illeginni, KI = Kwajalein, LG = Legan, MAC = Mid-Atoll Corridor, MK = Meck, OM = Omelek, RN = Roi Namur

2.5.1 Giant Clam (Hippopus hippopus)

Species Description. *Hippopus hippopus* are giant clams in the family Cardiidae. These filter feeding bivalves consume plankton; however, in many giant clams, much of their nutrition is obtained from their photosynthetic zooxanthellae symbionts (Klumpp and Lucas 1994). These mollusks are hermaphrodite broadcast spawners, releasing gametes into the water on a seasonal basis at least in the northern and southern limits of their range (Meadows 2016). *Hippopus hippopus* is known to spawn in the austral summer months (December to March) on the Great Barrier Reef but has been known to spawn in June near Palau (Meadows 2016). Fertilized eggs hatch into trochophore larvae which, within a few days, develop into bivalve veligers that feed on plankton (Ellis 1997). Eight to 14 days post fertilization, these veligers metamorphose into juvenile clams that settle on the substrate and acquire mutualistic zooxanthellae (Ellis 1997). The photosynthetic zooxanthellae reside in the mantle of the giant clams where they contribute to clam growth (Mies et al. 2012, Meadows 2016).

Distribution. *Hippopus hippopus* is widely distributed in shallow reef habitats throughout the tropical Indo-Pacific from Burma to the Marshall Islands and from the northern Philippines to New Caledonia (Munro 1993). This species is known to occur in the Marshall Islands, Micronesia, Palau, the Solomon Islands, and Vanuatu but is possibly extirpated from American Samoa, Fiji, Guam, and the Northern Mariana Islands (IUCN 2018). *Hippopus hippopus* is found in a wide range of habitats including lagoon or fringing reefs, sandy lagoon floors, or exposed intertidal habitats (Munro 1993). It is typically found at depths less than 20 m (66 ft) (Meadows 2016).

Threats. The major threats for this species include habitat degradation in the form of sedimentation and pollution; harvesting for subsistence, commercial fisheries, the aquarium trade, and the curio trade; and threats from global climate change including bleaching of their symbiotic zooxanthellae and shell degradation from ocean acidification (Meadows 2016).

Populations near Illeginni Islet. During NMFS surveys of the reef habitats offshore of the terrestrial impact zone at Illeginni Islet, this species was observed at low densities in both ocean-side and lagoon-side reef areas (**Table 7**, NMFS-PIRO 2017b). *Hippopus hippopus* was observed at all 11 of the surveyed Kwajalein Atoll islets since 2010 as well as at survey sites in the Mid-Atoll Corridor (**Table 8**). Since 2010, *Hippopus hippopus* individuals have been observed at 47 of 125 survey sites (38%) throughout Kwajalein Atoll. This species was recorded at 40% of sites (2 of 5) at Illeginni Islet, during biennial inventories; on lagoon-side reef crest and slope habitat as well as in Illeginni Harbor.

2.5.2 Black-lipped pearl oyster (Pinctada margaritifera)

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

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

Threats. *Pinctada margaritifera* are subject to predation by specialist invertebrates and vertebrates, particularly octopus, sea stars, and some fish. The black-lipped pearl oyster is intensively fished for pearls and nacre (mother of pearl). Wild populations are dramatically reduced from historical baselines. For example, between 1928 and 1930 at Pearl and Hermes Atolls (in the Northwest Hawaiian Islands), at least 150,000 black-lipped pearl oysters were harvested for pearls and nacre, primarily for making buttons. The same locations in 2003 had approximately 1,000 of these oysters (Keenan et al. 2006). The pearl industry throughout the Pacific now relies heavily on cultivated oyster farms, but wild harvest continues, and population recoveries have not been reported.

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

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

2.5.3 Top Shell Snail (Tectus niloticus)

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

Distribution. *Tectus niloticus* occurs throughout the Indo-Pacific and due to its commercial value, it has been translocated or introduced to many Indo-Pacific regions. Reproduction of mollusks often includes a free-swimming stage (veliger) enabling dispersal over great distances, and genetic similarity across most mollusk species' ranges indicates that long-distance dispersal occurs with regularity. Dispersal on smaller spatial scales of tens of kilometers is much more common (Cowen and Sponaugle 2009, Mumby and Steneck 2008).

Threats. All members of the family Tegulidae are subject to predation by specialist invertebrates and vertebrates, but principally by octopus and triggerfish (Family Balistidae). The rate of predation decreases as the animals grow, and it is thought that the largest individuals are not preyed on because there are no predators large enough to take them (McClanahan 1990). All members of the family Tegulidae, including *Tectus niloticus*, are also subject to fishing pressure for food and for the aquarium and curio trades (Tardy et al. 2008). This has led to widespread declines of top shell snails near human populations and to regional extinctions on small reef habitats next to large human populations (e.g., all top shell snails on Guam and the Northern Mariana Islands) (Munro 1994, IUCN 2018).

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

Populations near Illeginni Islet. During NMFS surveys of the reef habitats offshore of the terrestrial impact zone at Illeginni Islet, this species was observed at low densities in lagoon-side reef areas (**Table 7**, NMFS-PIRO 2017a). *Tectus niloticus* was observed at all 11 of the Kwajalein Atoll islets as well as on reefs in the Mid-Atoll Corridor (**Table 8**). *Tectus niloticus* is fairly widespread and common. Since 2008, *T. niloticus* individuals have been observed at 59 of 103 survey sites throughout Kwajalein Atoll during biennial inventories, including all four survey sites at Illeginni islet.

2.5.4 Giant Clam (Tridacna gigas)

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

Distribution. *Tridacna gigas* was historically widely distributed in shallow reef habitats throughout the tropical Indo-Pacific (Munro 1993) from Burma to the Marshall Islands and from Japan to New Caledonia (Meadows 2016). This species is known to occur in the Marshall Islands, Micronesia, Palau, and the Solomon Islands but is possibly extirpated from Fiji, Guam, Vanuatu, New Caledonia, and the Northern Mariana Islands (Munro 1993, IUCN 2018). *Tridacna gigas* is found in a wide range of habitats including high- and low-islands and lagoon or fringing reefs (Munro 1993). It is typically found at depths less than 20 m (66 ft) (Meadows 2016).

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

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

Populations near Illeginni Islet. *Tridacna gigas* was observed at all 11 of the surveyed Kwajalein Atoll islets since 2010 as well as on reefs in the Mid-Atoll Corridor (**Table 8**). While found at all islets, *Tridacna gigas* had a relatively low distribution at these islets; being found at only 22% of surveyed sites (28 of 125) throughout Kwajalein Atoll. This species was found at 40% of biennial inventory sites (2 of 5) at Illeginni Islet, including at a lagoon reef crest site and in Illeginni Harbor (**Table 8**) but was not observed in 2014 surveys near the Illeginni Islet impact zone.

2.5.5 Giant Clam (Tridacna squamosa)

Species Description. *Tridacna squamosa* is a giant clam species in the family Cardiidae that reaches more than 35 cm (14 in) (Munro 1993). These filter feeding bivalves consume plankton; however, in many giant clams, much of their nutrition is obtained from their photosynthetic zooxanthellae symbionts (Klumpp and Lucas 1994). These mollusks are hermaphrodite broadcast spawners, releasing gametes into the water (Meadows 2016). Spawning phenology for this species is unknown for most areas. Fertilized eggs hatch into trochophore larvae which, within a few days, develop into bivalve veligers that feed on plankton (Ellis 1997). These veligers then metamorphose into juvenile clams that settle on the substrate and acquire mutualistic zooxanthellae (Ellis 1997). In *T. squamosa*, 80% of larvae had settled by 13-days post fertilization and no swimming was observed in larvae greater than 14 days old (Neo et al.

2015). The photosynthetic zooxanthellae reside in the mantle of the giant clams where they contribute to clam growth (Mies et al. 2012, Meadows 2016).

Distribution. *Tridacna squamosa* has a wide but fairly limited distribution. This species is found in shallow reef habitats from west Africa to French Polynesia and the East China Sea to the Great Barrier Reef (Meadows 2016). This species is known to occur in the Marshall Islands, Micronesia, Palau, Vanuatu, and the Solomon Islands but is possibly extirpated from Japan and the Northern Mariana Islands (IUCN 2018). Tridacna squamosa is found in sheltered lagoon environments adjacent to high islands and larvae may prefer substrate with crustose coralline algae (Meadows 2016). This species is typically found at depths less than 20 m (66 ft) (Meadows 2016).

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

Populations near Illeginni Islet. During NMFS surveys of the reef habitats offshore of the terrestrial impact zone at Illeginni Islet, this species was observed at low densities in lagoon-side reef areas (**Table 7**) (NMFS-PIRO 2017a). *Tridacna squamosa* was observed at 9 of the 11 surveyed Kwajalein Atoll islets since 2010 as well as on reefs in the Mid-Atoll Corridor (**Table 8**). This species was recorded at 42 percent (52 of 125) of sites throughout Kwajalein Atoll. *Tridacna squamosa* was found at 60% (3 of 5) of sites at Illeginni Islet, including in lagoon reef crest and both lagoon and ocean slope habitats as well as in Illeginni Harbor.

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4.0 List of Preparers

Karen Hoksbergen, Biologist, KFS, LLC
M.S., 2004, Biology, Northern Michigan University
B.S., 2001, Biology and Wildlife, University of Wisconsin Stevens Point
Years of Experience: 19

Amy McEniry, Technical Editor, KFS, LLC
B.S., 1988, Biology, University of Alabama in Huntsville
Years of Experience: 32

Christopher W. Scott, Biologist, TMS, LLC
M.S., 2019, Environmental Biology, Regis University,
B.A., 2010, Criminology, University of South Florida
Years of Experience: 1

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